$$
c_{0}^{\lambda^{\lambda^{V}}}
$$

## MANUAL

# UF <br> <br> MINERALOGY ANİ LITHOLOGY 

 <br> <br> MINERALOGY ANİ LITHOLOGY}

CONTAININOTHE

ELEMESTS OF THE S'IENOR OF MNERALS AND ROCKS.<br>EOH I HF VSE WF <br>> BY JAMES D. DANA.<br>Iflity<br>Thustrated the Rumeraus anoodents.<br>> LoNDON:<br>THÜBNER \& ('O., LUI)GATE HILL 1885.<br>| Ah rists racmed.|

Eatiment presss
1.A1IANIVNA, HANGON ANは (C.


## PREFACE.

TIIs Manual in its present shape is new throsehout. In the renovation it has undergone, new illust rations have bern introduced, an inproved arrangement of the speeites has been adoped, the table for the detormination of minerals has been reconstructed, and the chaper on rocks has been expanded to a leogth and fullness that rembers it a prominent part of the work. Bat while modified greatly in all its parts. it is sthll simple in its mothods of presonting the facts in crys. tallography, atut on oflor exphanations ; and special proninence is given, us in former editions, to the more common mitacrals, with only a briof mention of othere. The old practical foature is retaned of pheing the ores under the prominent metal they eontain, and of giving in connection some information as to mines and mining industry

The student is refered to the Text-book of Minaralogy, prepared mainly hy Mr E. S lana, for a detailed exposition of the subject of erystallography after Namman's and Millores systems, and also of optical momeralogy and other physical branches of the seionce; to the Manual of Detorminative Mineralory and Blawpipe Analysis by Professor (iforae J Barsir, for a therough work on the use af the howpipe. and romplete tables for the determination of minerals, and to the authors leseriptive Mineralogy add its Appendixes fur a comprehensive treatise on all known minerals

JNMES D. MANA.

New Haten. Nov. 1, 1676.

## TABLE OF CONTENT:

MINERAlog Y.
Minfrals: General Remarhs
pesint ..... 1

1. CRYNYAIAIZATION OF MINERALS: (TYSTALLOGRAPIV:
2. Gomeral Remarhs on (rystallization ..... 4
3. Descriptions of (rystals. ..... 8
Dxplanation of Temms ..... y
Measurment of Amgles; Gonimmeters ..... 9

ture of ('rystals ..... 11
4. Isometric Systom. ..... 12
5. Dimetrie or 'letragonal System ..... 3
6. Trimetric or Orthorhombie Systom ..... 3
7. Monoclinic: Systrm ..... (1)
8. Triclinie System ..... 4:3
9. Hexigronal System ..... 4.5
10. Hexaronal Sertion ..... 46
11. Lhombohedral Section ..... 4)
7 Distingrashing (haracters of the Systems. ..... 5.4
 ..... 5
IIJ. Chystalaine Agalegates ..... 5
II. PIYNICAL PROPERTLES OF MCNETAAL
12. Mardness ..... 63
13. Temacity ..... 64
14. Specific Gravity ..... 64
15. Re-fraction and Polarization ..... 60
16. Diaphaneity, Lustre, Color ..... 70
(6) Electricity and Magnetiom ..... 78
17. Taste, Odur ..... 74

## III. (HEMCAL PROPERTIES OF MINERALS

pacis

1. Chemical Composition ..... 86
2. Chomical Ractions ..... 81
3. Trials in the Wet Way ..... 81
?. Trials with the Blowripe ..... 8:
IV hescriptions of minerals.
4. Cassificution ..... 1
5. General Remarks on Ores ..... 跂
I. Menemis consisting of the Aetme Eleqents.
6. Sulphur (iroup ..... 94
7. Borm (iroup ..... 9
8. Arsenic (iroup) ..... 98
4 Carimo Group ..... 102
 on withort Actbr -The Shele dtes Lach med.
Gold ..... 109
Silver and its Compounds. ..... 1119
Platinum, Iridium, linthenimm ..... 129
Talladiam ..... 137
Mercury and ite Componds ..... 128
Copper and its Compounds ..... 1:30
Lead and ita (omponnds. ..... 145
Zine and its Compomds. ..... 1.5
Codmium, Tin ..... 159
Compomots of Titaniun ..... 163
Cobah and Nickel and their Compounds ..... $10: 3$
Tranium and its Compenuds. ..... 16)
Irom and its Componds ..... 171
Manganse and its compowds. ..... 184
Compounds of Alaminum. ..... $19 \%$
Compunds of Cerium, Litrium, Erbium, Lanthanum and Didymium ..... 201
Compounds of Magnesiam. ..... 914
Componds of Calcium. ..... 207
Compounds of Barium and Strontiom ..... 220
Compounds of Potarsium and Sodiam ..... 223
Compounds of Ammonium ..... 230
Compounds of Hydrogen ..... 2:11
iII. Silica and Milicatlo.
9. SHICA. PAGE
Quartz ..... 238
Opal ..... $23!$
10. SLLICATES.
General Remarks. ..... 21:
11. Anhydrous Silicates.
1 Bisilicates ..... 243
Pyros: ne and Amphibole Group. ..... 24
Beryl, etc. ..... 25
2 Thisilicater. ..... 251
Clarysolite (iroup ..... 250
Garmet (Tromp) ..... 2.6
Zircon (droup ..... 2\%9
Jdormate. Fijidote, ate ..... 261
Axintre, lonite ..... 264
Masa (ironj) ..... $2(65$
Scupolitr (ironp ..... 36 s
Nephelite, Sondalite. Leucite ..... 249
Foldspar (iroup. ..... 272
12. Subsilicator ..... 2-4)
Chondrodjat, Tourmaline ..... 251
Audalusite, Eiboslite, ('yanite ..... 281
Tojaz, Euclase ..... 20
Datolite. Sthene, Staurolite ..... 280
13. Hydrous Silicates.
1 General Section ..... 992
Pertolite, Lammontitr, Apoplyylite ..... 293
Prehnite. Allophane ..... 20.)
14. Jeolite Section ..... 297
'Phomsonite, Natrolite, Analrite, Chabazite ..... 298
Harmotomes, stilbite, Heukandite ..... 301
¿. Margaroplyllite Section ..... 304
Tale, Py rophyllite, sepiolite ..... 301
Serpentine, Deweylite, Saponite ..... $30 \%$
Kialinite. Pinito. ..... ?10
Mydromica (iroup ..... 812
Fahlunite, llisingerite ..... $31 \%$
Chlorite Group. ..... 316
IT. Ilydrocarbon Compounds.
fatie
15. Simple Hydrocarbons ..... 321
16. Oxygenated Hydrocarbons ..... 325
17. Asphaltum and Mineral C'oals. ..... 326
Suplement to IDenchiptions of Speotes.
1 Catalogue of American Localities of Minerals ..... 333
18. Brief Notice of Foreign Mining Regrious. ..... 375
IV. DETERMINATION OF MINERALS.
General Remarks ..... 379
Table for the Determination of Minerals ..... 384
0 N ROUKS.
19. Constituents of Rocks ..... 409
20. Classes of Rocks ..... 412
21. On sone 'haraeteristics of Rocks ..... 414
Use of the Microscope in the study of hooks. ..... 42
22. Kinds of Rucks ..... 424
23. Fragmental Rocks, exclusive of Limestones ..... 426
24. Limestont's or ('alcareous Rocks ..... 430
25. Crystalline Rocks, exclusive of Limestones. ..... 484
26. Silicerus Rocks. ..... 43.3
27. Mica and Potash-Feldepar Series ..... $48 \%$
28. Mica and Soda-lime Feldepar Series ..... 443
29. Hornblende and Potanh-Feldspar Scrips. ..... 444
30. Hornblende and Sinda-lime Feldspar sicries ..... 446
31. Pyroxene and Soda-lime Feldspar Series.. ..... 450
32. Pyrosene, Gamet, Epidote, and (hrysolite Rocks, containing little or no Feldspar. ..... 452
33. Hydrous Magnesian and Aluminous Rocks. ..... 453
34. Irun-ore Rucks ..... 405

## MINEIRALOGY.

## Minerals.

Minerals are the materials of which the earth consists, and plants and anmals the living beings over the surface of the mineral-made glole:. A fiow rocks, like limestone and quartzyte, consist of a simble mineral in more or less pure state; but the most of them are mixtures of two or bore minerals. Through rocks of each hind various other minerals are often distributed, either in a seatlered way, or in vems and cavities. Gems are the minerais of jowelry; and ores, those that are important for the metal they contain. Water is a mineral, but generatly in an impure state from the presence of other minerals in solution. Tho atmosphere, and all gaseous materials sot free in voleanic and other regions, are mineral in mature, although, berause of their invisibility, schom to be found atoong the specimens of mineral cabmets. Even fossils are mineral in composition This is true of coal whith has come from harted plat-heds, and amber from the huided resin of ancient trees, as well as of fossil shells and (amals.

It is sometimes sad that minerals belong to the mineral kinglom, as phants to the vegetable kinglom, and aninals to the animal kingdom. Substitating the trom inorgonie for mineral, the statement is right; for, ass there are the two kingloms of life, so there is in Nature what moy he eallod a kinglom, or grand division, includine all species not made through the organzing principle of life. But this inorganic kingdom is not restricted to minerals; it embraces all species mado by inorgranc fonces-those of the earth's crust or surface, and, also, whatever may form under the manipulations of the chemist. The laws of composition and structure, exemplified in the constitution of rocks, are those also of the laboratory. A species made
ly art, as we term it, is not a product of art, but a result solely of the fundamental laws of composition which are at the basis of all material existence; and the chemist only supplies the fivorable conditions for the action of those laws. Mineral species, are then, but a very small part of those which make up the inorganic kinglom or division of Nature.

## Cnaracters of Minerals.

1. Minerals, mulike most rocks, have a definite chemical composition. This composition, as determined by rhemical amalysis, serves to define and distinguish the species, and indicates their profoundest relations. ()wing to ditterence in composition, minerals exhihit great differenees when heated, and when subjected to varous chemical reagents, and these peruliarities are a means of determining the kind of mineral under exumination in any case. The department of the srience treating of the composition of minerals and their chemical reactions is termed Chmmeal Mineralogy.
2. Earh mineral, with few exceptions, has its definite form, by which, when in good specimens, it may bo known, and as truly so as a dog or cat. These forms are cubes, prisms, double pyramids, and the like. They are inchuded undre phene surfaces arranged in symmetrical order, aceording to mathematical law. These forms, in the mineral kingdom, are called roystals. Berides form there is also, as in living individuals, a distinctave internal structure for atch species. 'The facts of this branch of ther science come under the head of Coystallourapulo: MinereAlogr.
3. Minerals differ in hardiness-from the diamond at one end of the scale to soapstone at the other. There is a still lower linit in liquids and gases; but of the hardue'ss or coleesion in this part of the serie's the mineralogist has little occasion to take note.

Minerals differ in sperific gravity, and this character, like harduess, is a most important means of distinguishing species.

Minerals differ in color, transparency, lustre, and other optical characters.

A few minerals have taste and odor, and when so these characters are noticed in descriptions.

The facts and principles relating to the above characters are embraced in the department of Physical Mineradogy.

In addition to the above-mentioned branches of the seience
of minerals there is also (4) that of Descmiptive Mineralogy, under which are included descriptions of the mineral species; and (5) that of Detemminative Mineralogy, which gives a systematic review of the methods for determining or distinguishing minerals.

These duferent branches of the subject are here taken up in the following order: I. Crystallographic Mineralogy; JI. Physical Nineralogy; III. Chemical Mineralogy; IV. Descriptive Mincralogs ; V. Determinative Mineralogy. On account of the lorif manner in which the subjects are treated in this volume, the heats used for the several pats are, (1) The Orys. talliantion of Mincrals; (シ) Physical Iroprties at Minerals; (3) Chomiral I'roperties of Minerals ; (4) Itescriptions of sipecies ; (i) Determinution of Hincrals.

## 1. CRYsTALLIZATION OF MINERAIS: CRYSTALLO(iRAPIIY.

## 1. (iendral Mmmaks on ('rystallization.

Tire attraction which produces crrstals is one of the functamental properties of mather. It is idnotical whth the eohesion of ordinary solidification; for there are fow cases outside of the kingdons of life in which solditication takes phase without some degree of crystallization. Cohesive attraction is, in fart, the wgrazing or structur making principle in incrganir nature, it producing specifice forms for cach specios of mattor, at life dowe for ach hoving sereins. A har of cast iron is romoh and hackly in surface, because of the amolar crystollime grans which the iron assmod as soliditieation took phare. A frasmont of marble glistens in the sm, owing to the reflection of light from innumerable crystalline surfaces, every grain in the mass hating its crystalline structure. When the coldi of winter sothes over the earth in the higher temperate: and ...hher latitmen, it is the


CHYST hIS OF SNOW.
signal for erystallization over all out-foor nature ; the air is filled with crystal flakes when it surows; the streams become coated with an aggregation of crystals called ico ; and windows are covered with frost because crystal has been added to crystal
in long feathered lines over the glass-Jack Frost's work being the making of erystals. Water camot solidify without crystallising, and neither can iron nor lead, nor any mineral material, with perhaps half a dozen exceptions. Crystallization produces masses made of crystalline grains when it cannot make distinct crystals. (iranite mountains are mountains of crystals, each partide being crysalline in nature and structure. Tue lava courrent, as it comb, becomes a mass of crystalline grains. In fint the carth may be said to have erystal foundations; and if there is not the beaty of external fom, there is everywhere the interior, pofommer beanty of miversal law-h her same law of symmetry which, when axternal cincmustanes pernit, leads to) the perfect arstad with regular facets and angles.
(rystals are alone in making known the fact that this haw of symmetry is one of the laws of cobesine attraction, and that moder it this attraction not only beings the patiches of matter into forms of mathematical symmetry, but of en develops scome; of brillant facets ow their surfare with mathematical exactness of angle, and the simplent of momeleal relations in them poritions. Crystade henh alow the more wonderful fact that the same speries of mather may reeive, under the artion of this attraction, through some yet incomprehemsible changes in its condition, a great divensty of forms-from the selded of half a dozen phanes to on of somes. The following tigures represent a fow of the forms in a common species, pyrite, a compound of iron and sulphur.


14.


Many more figures might be given for this one species, pyrite. The various forms or planes in any such case have, it is true, mutually dependent relations-a fact often expressed by saying that they have a common fundamental form. But it is none the less a remarkable fact, giving profound interest to the subject, that the attraction, while having this degree of nnity in any species, still, under each, admits of the multitudinous variations needed to produce so diverse results.

At the time of crystallization the material is usually in a
state of fusion, or of gas or vapor, or of solution. In the case of iron the crystallization takes place from a state of fusion, and while the result is ordinarily only a mass of crystalline grains, distinct crystals are sometimes formed in any cavities. If in the cooling of a crucible of melted lead, bismuth, or sulphur, the crust be broken soon after it forms, and the liquid part within be turned out, crystals will be found covering the interior. Here, also, is crystallization from a state of fusion. When frost or snow-flakes form it exemplifies crystallization from a state of vapor. If a saturated solution of alum, made with hot water, be left to cool, crystals of alum after awhile will appear, and will become of large size if there is enough of the solution. A solution of common salt, or of sugar, affords crystals in the same way. Again, whenever a mineral is produced through the change or decomposition of another, and at the same time assumes the solid state, it takes at once a crystalline structure, if it does not also develop crystals.

Further, the crystalline texture of a solid mass may often be changed without fusion: e. g., in tempering steel the bar is changed from coarse-grained steel to finc-grained by heating aud then cooling it suddenly in cold water, and vice versa, and this is a change in every grain throughout the bar.

Thus the various processes of solidification are processes of crystallization, and the most universal of all facts about minerals is that they are crystalline in texture. A few exceptions have been alluded to, and one example of these is the mineral opal, in which even the microscope detects no evidence of a crystalline condition, except sometimes in minute portions supposed not to be opal. But if we exclude coals and resins this mineral stands almost alone. Such facts, therefore, do not affect the conclusion that a knowledge of crystallography is of the highest importance to the mineralogist. It is important because-

1. A study of the crystalline forms and structure of minerals is a convenient means of distinguishing species-the crystals of a species being essentially constant in structure and in angles.
2. The most important optical characters depend on the crystallization, and have to be learned from crystals.
3. The profoundest chemical relations of minerals are often exhibited in the relations of their crystalline forms.
4. Crystallization opens to us nature at her foundation work and illustrates its mathematical character.

## 2. Deschiptions of Crystals.

In describing crystals there are two subjects for consideration: First, Form; and secondly, Structure.
A. Form.-Under form come up for description, not only the general forms of crystals, but also-
(1.) The systems of crystallization, that is, the relations of all crystalline forms, and their classification.
(2.) The mutual relations of the planes of a crystal as ascertained through their positions and the angles between them.
(3.) The distortions of crystals. The perfection of symmetry exhibited in the figures of crystals, in which all similar planes are represented as having the same size and form, is seldom found in nature, and the true form is often greatly disguised by this means. The facts on this point, and the methods of avoiding wrong conclusions need to be understood, and these are given beyond. With all such imperfections the angles of crystals remain essentially constant. There ard irregularities also from other sources.
(4.) Twin or compound crystals. With some species twins are more common than regular crystals.
(5.) Crystalline aggregates, or combinations of imperfect crystals, or of crystalline grains.

## Explanations of Terms.

The following are explanations of a few terms used in connection with this subject:

1. Octahedron.-A solid bounded by eight equal triangles. They are equal equilateral triangles in the regular octahedron (Fig. 2, p. 17); equal isosceles triangles in the square octahedron (Fig. 17, p 32); equal inequilateral triangles in the rhombic octahedron (Fig. 8, p. 37).
2. Double six-sided pyramids. Double cight-sided pyramids. Double twelve-sided pyramids.-Solids made of two equal equilateral six-sided, or eight-sided, or twelve-sided, pyramids placed base to base (Fig. 20, p. 32, and 6, 10, pp. 46, 47).
3. Right prisms. Oblique prisms.-Right prisms are those that are erect, all their sides being at right angles to the base. When inclined, they are called oblique prisms.
4. Interfacial angle. - Angle of inclination between two faces or planes.
5. Similar planes. Similar angles.- The lateral faces of a square prism (Fig. 2, p. 14) are equal and have like relations to the axes, and hence they are said to be similar. Solid angles are similar when the plane angles are equal each for each, and the enclosing planes are severally similar in their relations to the axes.
6. Truncated. Bevelled.-An edge of a crystal is said to be truncated when it is replaced by a plane equally inclined to the enclosing planes, as in Fig. 13, p. 10 ; and it is bevelled when replaced by two planes
equally inclined severally to the adjoining faces. Only edges that are formed by the meeting of two similar planes oan be truncated or bevelled. The angle between the truncating plane and the plane adjoining it on either side always equals $90^{\circ} p l u s$ half the interfacial angle over the truncated edge. When a rectangular edge, or one of $90^{\circ}$, is truncated, this angle is acoordingly $135^{\circ}\left(=90^{\circ}+45^{\circ}\right)$; when an edge of $70^{\circ}$, it is $125^{\circ}\left(=90^{\circ}+35^{\circ}\right)$; when an edge of $140^{\circ}$, it is $160^{\circ}\left(=90^{\circ}+70^{\circ}\right)$.
7. Zone.-A zone of planes includes a series of planes having the edges between them, that is, their mutual intersections, all parallel. Thus in Fig. 14, on page 6, $O$ at top of figure, $i 2, i=O$ in front, and two planes below, and others on the back of the crystal are in one zone, a vertical zone. Again, in the same figure, 0 at top, $42,33,22,42, i 2,42$, 22,33 , and the continuation of this series below and over the back of the crystal lie in another vertical zone. And so in other cases, in other directions. All planes in the same zone may be viewed as on the circumference of the same circle. The planes of crystals are generally all comprised in a few zones, and the study of the mathematics of crystals is largely the study of zones of planes.

Axes.-Imaginary lines in crystals intersecting one another at their centres. Axes are assumed in order to describe the positions of the planes of crystals. In each system of crystallization there is one vertical axis, and in all but hexagonal forms there are two lateral axes.

Diametral sections. - The sections of crystals in which lie any two of the axes. In forms having two lateral axes, there are two vertical diametral sections and one basal.

Diametral prisms.-Prisms whose sides are parallel to the diametral sections.

## - Measurement of Angles.

The angles of crystals are measured by means of instruments called goniometers. These instruments are of two kinds, one the common goniometcr, the other, the reflecting goniometcr.

The conmon goniometer depends for its use on the very simple principle that when two straight lines cross one another, as A E, C D, in the annexed figure, the parts will diverge equally on opposite sides of the point of intersection ( 0 ) ; that is in mathematical language, the augle A O D is equal to the angle COE,
 and AOC is equal to DOE.

A common form of the instrument is represented in the figure on page 10 .

The two arms ab,cd, move on a pivot at $a$, and their divergence, or the anglo they make with one another, is read off on the graduated are attached. In using it, pross up between the edges $a 0$ and $c o$, the edge of the crystal whose angle is to be pueasured, and continue thus opening the arms until these edges lie evendy against the faces that include the required angle. To insure accuracy in this respect, hold the instrament and crystal between the eye and the light, and observe that no light passes between the arm and the applied faces of the crystal. The arms may then be secured in position by tightening the screw at $o$; the angle will then be measured by the distance on the arc from $\hat{R}$ to the left or outer edge of the arm $c d$, this edge being in of $Q$, the centre of motion. As the instrument stands in the
figure, it reads $45^{\circ}$. The arms have slits at $g h, n p$, by which the parts ao, co, may be shortened so as to make them more convenient for measuring small crystals.

In the best form of the common goniometer the are is a complete

circle, of larger diameter than in the above figure, and the arms are separate from it. After making the measurement, the arms are laid upon the circle, with the pivot at the centre of motion inserted in a socket at the centre of the circle. The inner edge of one of the arms is then brought to zero on the circle, and the angle is read off as before.

With a little ingenuity the student may construct a goniometer for himself that will answer a good purpose. A semicircle may be described on mica or a glazed card, and graduated. The arms might also be made of stiff card for temporary ase; but mica, bone, or metal is better. The arms should have the edges straight and accurately parallel, and be pivoted together. The instrument may be used like that last described, and will give approximate results, safficiently near for distinguishing most minerals. The ivory rule accompanying boxes of mathematical instruments, having upon it a scale of sines for measuring angles, will answer an excellent purpose, and is as convenient as the arc.
In making such measurements it is important to have in mind the fact that-

1. The sam of the angles about a centre is $360^{\circ}$.
2. In a rhomb, as in a square, the sum of the plane angles is $360^{\circ}$.

In any polygon, the supplements of the angles equals $360^{\circ}$, whatever the number of sides. For example: in a square, the four angles are each $90^{\circ}$, and hence the supplements are $90^{\circ}$, and $4 \times 90=360$; again, in a regular hexagon the six angles are each 120, the supplements are $60^{\circ}$, and $6 \times 60=360$. So for all polygons, whether regular or irregular. In measuring the angles it is therefore convenient to take down the supplements of the angles. This principle is conveniently applied in the measurement of all the angles of a zone of planes around the crystal; for the sum of all the supplements should be, as above, $360^{\circ}$; and if this resalt is not obtained there is error somewhere.

The reflecting gonimeter affords a more accurate method of measuring crystals that have lustre, and may be used with those of minute size. The principle on whioh this instrament is constructed will be anderstood from the annexed figure, representing a crystal,
 whose angle $a b c$ is required. The eye, looking at the face of the crystal $b c$, observes a reflected image of $m$, in the direction $\mathrm{P} n$. On revolving the crystal till $a b$ has the position of $b c$, the same image will be seen again in the same direction $P$ n. As the crystal is turned, in this revolution, till $a b d$ has the present position of $b c$, the angle $d b c$ measures the number of degrees through which it is revolved. But $d b$ o subtracted from $180^{\circ}$ equals the angle of the crystal $a b c$. The crystal is therefore passed, in its revolution, through a number of degrees equal to the supplement of the required angle.

This angle, in the reflecting goniometer of Wollaston, is measured by attaching the crystal to a graduated circle which revolves with it, one form of which is here represented.


0 is the graduated circle. The wheel, $m$, is attached to the main axis, and moves the graduated circle together with the adjusted crystal.

The wheel, $n$, is connected with an axis which passes through the main axis (which is hollow for the purpose), and moves merely the parts to which the crystal is attached. in order to assist in its adjustment. The contrivances for the adjustment of the crystal are at $a, b$, $c_{0} d, k$. The screws, $c, d$, are for the adjustment of the crystal, and the slides, $a, b$, serve to centre it.

To use the instrument, it may be put on a stand or small table, with its base accurately horizontal, and the table placed in front of a window, six to twelve feet off, with the plane of its circle at right angles to the window. A dark line must then be drawn below the window, near the floor, parallel to the bars of the window, and about as far from the eye as from the window-bar.

The crystal is attached to the movable plate $k$ by means of wax, and so arranged that the edge of intersection of the two planes forming the required angle, shall be in a line with the axis of the instrument. This is done by varying its situation on the plate, or by means of the adjacent screws and slides.

When apparently adjusted, the eye must be brought close to the crystal, nearly in contact with it, and on looking into a face, part of the window will be seen reflected, one bar of which must be selected for the trial. If the crystal is correctly adjusted, the selected bar will appear horizontal, and on turning the wheel $n$, till this bar, as reflectecl, is observed to approach the dark line below seen in a direct view, it will be found to be parallel to this dark line, and ultimately to coincide with it. The eye for both observations should be held in precisely the same position. If there is not a perfect coincidence, the adjustment must be altered until this coincidence is obtained. Continue then the revolution of the wheel $n$, till the same bar is seen by reflection in the next face, and if here there is also a coincidence of the reflected bar with the dark line seen direct, the adjustment is complete; if not, alteratious must be made, and the first face again tried. In an instrument like the one figured, the circle is usually graduated to twenty or thirty minutes, and, by means of the vernier, minutes and half minutes are measured. After adjustment, $180^{\circ}$ on the arc must be brought opposite 0 , on the vernier, $v$. The coincidence of the bar and dark line is then to be obtained, by turning the wheel $n$. When obtained, the wheel $m$ should be turned until the same coincidence is observed, by means of the next face of the crystal. If a line on the graduated circle now corresponds with 0 on the vernier, the angle is immediately determined by the number of degrees opposite this line. If no line corresponds with 0 , we must observe which line on the vernier coincides with one on the circle. If it is the 18th on the vermier, and the line on the circle next below 0 on the vernier marks $125^{\circ}$, the required angle is $125^{\circ} 18^{\prime}$; if this latter line marks $125^{\circ} 20^{\prime}$, the required angle is $125^{\circ} 38^{\prime}$.
In the better instruments other improved methods of arrangement are employed; and in the best, often called Mitscherlich's goniometer, because first devised by him, there are two telescopes, one for passing a ray of light upon the adjusted crystal, having crossed hair lines in its locus, and the other for viewing it, also with a hair cross. With such an arrangement, the window-bar and dark line are unnecessary, the hair crosses serving to fix the position of the crystal, and the telescope that of the eye. If the crystal is perfect in its planes, and the adjust-
ment exact, the measurement, with the best instruments, will give the angle within $10^{\prime \prime}$.
Other goniometers have only the second of the two telescopes just alluded to, as is the case in the figure on page 11. This telescope gives a fixed position to the eye; and through it is seen a reflection of some distant object, which may be even a chimney-top. For the measurement the object, seen reflected in the two planes successively, is brought each time into conjunction with the hair cross. Exact adjustment is absolutely essential, and with an instrument having the two telescopes, the first step in a measurement cannot be taken without it.

Only small, well-polished crystals can be accurately measured by the reflecting goniometer. If, when using the instrument without telescopes, the faces do not reflect distinctly a bar of the window, the flame of a caudle or of a gas-burner, placed at some distance from the crystal, may be used by observing the flash from it with the faces in succession as the circle is revolved. A ray of sun-light from a mirror, received on the crystal through a small hole, may be employed in a similar way. But the results of such measurements will be only approximations. With two telescopes and artificial light, and with a cross slit to let the light pass in place of the cross hairs of the first of the above-mentioned telescopes, this light cross will be reflected from the face of a crystal even when it is not perfect in polish, and quite good results may be obtained.
B. Structure.-Structure includes cleavage, a characteristic of crystals intimately connected with their forms and nature. It is the property, which many crystals have, of admitting of subdivision indefinitely in certain directions, and affording usually even, and frequently polished, surfaces. The direction is always parallel with the planes of the axes, or with others diagonal to these.

The ease with which cleavage can be obtained varies greatly in different minerals, and in different directions in the same mineral. In a few species, like mica, it readily yields laminie thinner than paper, and in this case the cleavage is said to bo eminent. Others, of perfect cleavage, cleave easily, but afford thicker plates, and from this stage there are all grades to that in which cleavage is barely discernible or difficult. The cleavage surfaces vary in lustre from the most brilliant to those that are nearly dull. When cleavage in a mineral is alike in two or more directions, that is, is attainable in these directions with equal facility and affords surfaces of like lustre and character or marking, this is proof that the planes in those directions are similar, or have similar relations to like axes. For example, equal cleavage in three directions, at right angles to one another, shows that the planes of cleavage correspond to the faces of the cube; so equal cleavage in two directions, in a prismatic mineral, shows that the planes in the two directions are those of a
square prism, or else of a rhombic prism; and if they are at right angles to one another that they are those of the former. This subject is further illustrated beyond.

In the following pages (1) the Systems of Crystallization and the Forms and Structure of Crystals are first considered ; next, (2) Compound, or Twin Crystals; and then (3) Crystalline Aggreg

## 1. SYSTEMS OF CRYSTALLIZATION: FORMS AND STRUCTURE OF CRYSTALS.

The forms of crystals are exceedingly various, while the systems of crystallization, based on their mathematical distinctions, are only six in number. Some of the simplest of the forms under these six systems are the prisms represented in the following figures; and by a study of these forms the distinctions

of the six systems will become apparent. These prisms are all four-sided, excepting the last, which is six-sided. In them the planes of the top and bottom, and any planes that might be made parallel to these, are called the basal planes, and the sides the lateral planes. An imaginary line joining the centres of the bases ( $c$ in figures 1 to 8 ) is called the vertical axis, and the
diagonals $a$ and $b$, drawn in a plane parallel to the base, are the lateral axes.

Fig. 1 represents a cube. It has all its planes square (like fig. 9), and all its plane and solid angles, right angles, and the three axes consequently cross at right angles (or, in other
9.
10.
11.

12.

words, make rectangular intersections) and are equal. It is an example under the tirst of the systems of crystallization, which system, in allusion to the equality of the axes, is called the Isometric system, from the Greek for equal and measure.

Fig. 2 represents an erect or right square prism having all its plane angles and solid angles rectangular. The base is square or a tetragon, and consequently the lateral axes are equal and rectangular in their intersections; but, unlike a cube, the vertical axis is unequal to the lateral. There are hence, in the square prism, axes of two kinds making rectangular intersections. The system is hence called, in allusion to the two kinds of axes, the İmetric system, or, in allusion to the tetragonal base, the TCtragonal system.

Fig. 3 represents an erect or right rectangular prism, in which, also, the plane angles and solid engles are rectangular. The base is a rectangle (fig. 10), and consequently the lateral axes, connecting the centres of the opposite lateral faces, are unequal and rectangular in their intersections; and, at the same time, each is unequal to the vertical. There are hence three unlike axes making rectangular intersections; and in allusion to the three unlike axes, the system is called the Trimetric system. It is also named, in allusion to its including erect prisms having a rhombic base, the Orthorhombic system, orthos, in Greek, signifying straight or erect.

This rhombic prism is represented in fig. 4. It has a rhombic base, like fig. 11; the lateral axes connect the centres of the opposite lateral edges; and hence they cross at right angles and are unequal, as in the rectangular prism. This right rhombic prism is therefore one in system with the right rectangular

Fig. 5 represents another rectangular prism, and fig. 6
another rhombic prism; but, unlike figs. 3 and 4, the prisms are inclined backward, and are therefore oblique prisms. The lateral axes ( $a, b$ ) are at right angles to one another and unequal, as in the preceding system; but the vertical axis is inclined to the plane of the lateral axes. It is inclined, however, to only one of the lateral axes, it being at right angles to the other. Hence, of the three angles of axial intersection, two are rectangular, namely $a$ on $b$, and $c$ on $b$, while one is oblique, that is $\boldsymbol{c}$ (the vertical axis) on $a$. In allusion to this fact, there being only one oblique angle, this system is called the Monoclinic system, from the Greek for one and inclined.

Fig. 7 represents an oblique prism with a rhomboidal base (like fig. 12). The three axes are unequal and the three axial intersections are all oblique. The system is called the Triclinic system, from the Greek for three and inclined.

Fig. 8 represents a six-sided prism, with the sides equal, and the base a regular hexagon. The lateral axes are here three in number. They intersect at angles of $60^{\circ}$; and this is so, whether these lateral axes be lines joining the centres of opposite lateral planes, or of opposite lateral edges, as a trial will show. The vertical axis is at right angles to the plane of the three lateral axes, inasmuch as the prism is erect or right. The base of the prism being a regular hexagon, the system is called the Hexagonal system.

The systems of crystallization are therefore:
I. The Isometric system : the three axes rectangular in intersections; equal.
II. The Dimetric or Tetragonal system : the three axes rectangular in intersections; the two lateral axes equal, and unequal to the vertical.
III. The Trimetric or Obthorhombic system : the three axes rectangular in intersections, and unequal.

TV. The Monoclinic system : only one oblique inclination out of the three made by the intersecting axes; the three axes unequal.
V. The Taiclinic system : all the three axes obliquely inclined to one another, and unequal.
VI. The Hexagonal syatem : the vertical axis at right angles to the lateral; the lateral three in number, and intersecting at angles of $60^{\circ}$.

These six systems of crystallization are based on mathematical distinctions, and the recognition of them is of great value in the study and description of crystals. Yet these distinctions are often of feeble importance, since they sometimes separate
species and crystalline forms that are very close in their relations. There are forms uuder each of the systems that differ but little in angles from some of other systems: for example, square prisms that vary but slightiy from the cubic form ; triclinic that are almost identical with monoclinic forms ; hexagonal that are nearly cubic. Consequently it is found that the same natural group of minerals may include both trimetric and monoclinic species, as is true of the Hornblende group; or monoclinio and triclinic, as is the fact with the Feldspar group, and so on. It is hence a point to be remembered, when the affinities of species are under consideration, that difference in crystallographic system is far from certain evidence that any species are fundamentally or widely unlike.

## I. THE ISOMETRIC SYSTEM.

1. Descriptions of Forms. The following are figures of some of the forms of crystals under the isomotric system:


The first is the cube or hexahedron, already described. Besides the three cubic axes, there are equal diagonals in two other directions; one set connecting the apices of the diagonally opposite solid angles, four in number (because the number of such angles is eight), and called the octahedral axes; and another set connecting the centres of the diagonally opposite
edges, six in number (because the number of edges is twelve), and called the dodecahedral axes.

Fig. 2 represents the octaledron, a solid contained under eight equal triangular faces (whence the name from the Greek oight and face), and having the three axes like those in the cube. Its plane angles are $60^{\circ}$; its interfacial angles, that is the inclination of planes 1 and 1 over an intervening edge, $109^{\circ} 28^{\prime}$; and 1 on 1 over a solid angle, $70^{\circ} 32^{\prime}$.

Fig. 3 is the dodecahedron, a solid contained under twelve equal rhombic faces (whence the name from the Greek for twelve and fuce). The position of the cubic axes is shown in the figure. It has fourteen solid angles; six formed by the meeting of four planes, and eight formed by the meeting of three. The interfacial angles (or $i$ on an adjoining $i$ ) are $120^{\circ} ; i$ on $i$ over a four-faced solid angle $=90^{\circ}$.

Fig. 4 is a trapezohedron, a solid contained under 24 equal trapezoidal faces. There are several different trapezohedrons among isometric crystalline forms. The one here figured, which is the common one, has the angle over the edge $B, 131^{\circ} 49^{\prime}$, and that over the edge $C, 146^{\circ} 27^{\prime}$. A trapezohedron is also called a tetrayonal trisoctahedron, the faces being tetragonal or four-sided, and the number of faces being 3 times 8 (tris, octo, in Greek).

Fig. 5 is another trisoctahedron, one having trigonal or threesided faces, and heuce called a trigonal trisoctahedron. Comparing it with the octahedron, fig. 2 , it will be seen that three of its planes correspond to one of the octahedron. The same is true also of the trapezohedron.

Fig. 6 is a tetrahexahedron, that is a $4 \times 6$-faced solid, the faces being 24 in number, and four corresponding to each face of the cube or hexahedron (fig. 1).

Fig. 7 is a hexoctahedron, that is a $6 \times 8$-faced solid, a pyramid of six planes corresponding to each face in the octahedron, as is apparent on comparison. There are different kinds of hexoctahedrons known among crystallized isometric species, as well as of the two preceding forms. In each case the difference is not in number or general arrangement of planes, but in the angles between the planes, as explained beyond.

But these simple forms very commonly occur in combination with one another; a cube with the planes of an octahedron and the reverse, or with the planes of any or all of the other kinds above figured, and many others besides. Moreover, all stages between the different forms are often represented among the crystals of a species. Thus between the cube and octahedron,
occur the forms shown in figs. 8 to 11. Fig. 12 is a cube; fig. 8 represents the cube with a plane on each angle, equally inclined to each cubic face; 9 , the same, with the planes on the angles more enlarged and the cubic faces reduced in size; and

then 10 , the octahedron, with the cubic faces quite small; and fig. 11, the octahedron, the cubic faces having disappeared altogether. This transformation is easily performed by the student with cubes cut out of chalk, clay, or a potato. It shows the fact that the cubic axes (fig. 12) connect the apices of the solid angles in the octahedron.

Again, leetween a cube and a dodecahedron there occur forms like figs. 13 and 14 ; fig. 12 being a cube, fig. 13 the same, with planes truncating the edges, each plane being equally inclined to the adjacent cubic faces, and fig. 14 another, with these planes on the edges large and the cubic faces small; and then, when the cubic faces disappear by farther enlargement of the planes on the edges, the form is a dodecahedron, fig. 15. The student should prove this transformation by trial with chalk or some other material, and so for other cases mentioned beyond. The surface of such models in chalk may be made hard by a coat of mucilage or varnish.

Again, between a cube and a trapezohedron there are the forms 17 and $18 ; 16$ being the cube, 17 , cube with three planes placed symmetrically on each augle; 18, the same with the cubic faces greatly reduced (but also with small octahedral faces), and 10, the trapezohedron, the cubic faces baving disappeared.

Again, fig. 20 represents a cube with three planes on each angle, which, if enlarged to the obliteration of the faces of the cube, become the trigonal trisoctahedron, fig. 21. So again, fig.
16.

17.

20.

21.

18.

22.

19.

23.


22 represents a cube with six faces on each angle, which, if enlarged to the same extent as in the last, would become the hexoctahedron, fig. 23.

Again, fig. 25 is a form between the octahedron (fig. 24) and

25.

dodecahedron (fig. 26) ; and figs. 27 and 28 are forms between the dodecahedron, fig. 26, and trapezohedron, fig. 29.

Again, fig. 30 is a form between a cube (fig. 16) and a tetrahexahedron, fig. 31 ; fig. 32, a form between an octahedron, fig. 24 , and a tetrahexahedron, fig. 31 ; fig. 33 , a form between an

32.

octahedron and a trigonal trisoctahedron, fig. 34 ; fig. 35, a form between a dodecahedron (planes $i$ ) and a tetrahexahedron; fig.
33.

36.

34.

37.

35.

38.


36, a form between the dodecahedron and a hoxoctahedron, fig. 37.

Fig. 38 represents a cube with planes of both the octahedron and dodecahedron.
2. Positions of planes with reference to the axes. "Lettering of figures. -The numbers by which the planes in the above figures, and others of the work, are lettered, indicate the positions of the planes with reference to the axes, and exhibit the mathematical symmetry and ratios in crystallization. In the figure of the cube (fig. 1) the three axes are represented; the lateral semi-axis which meets the front planes in the figure is lettered $a$; that meeting the side plane to the right $b$, aud the vertical axis $c$, and the other halves of the same axes respectively $-a,-b,-c$. By a study of the positions of the planes of the
cube and other forms with reference to these axes, the following facts will become apparent.

In the cube (fig. 1) the front plane touches the extremity of axis $a$, but is parallel to axes $b$ and $c$. When one line or plane is parallel to another they do not meet except at an infinite distance, and hence the sign for infinity is used to express parallelism. Employing $i$, the initial of infinity, as this sign, and writing $c, b, a$, for the semi-axes so lettered, then the position of this plane of the cube is indicated by the expression ic: $i b: 1 a$. The top and side-planes of the cube meet one axis and are parallel to the other two, and the same expression answers for each, if only the letters $a, b, c$, be changed to correspond with their positions. The opposite planes have the same expressions, except that the $c, b, a$ will refer to the opposite halves of the axes and be $-c,-b,-a$.

In the dodecahedron, fig. 15, the right of the two vertical front planes $i$. meets two axes, the axes $a$ and $b$, at their extremities, and is parallel to the axis $\sigma$. Hence the position of this plane is expressed by ic : $1 b: 1 a$. So, all the planes meet two axes similarly and are parallel to the third. The expression answers as well for the planes $i$ in figs. 13, 14, as for that of the dodecahedron, for the planes have all the same relation to the axes.
In the octahedron, fig. 11, the face 1, situated to the right above, like all the rest, meets the axes $a, b, c$, at their extremities; so that the expression $1 c: 1 b: 1 a$ answers for all.

Again, in fig. 17 (p.20) there are three planes, 2-2, placed symmetrically on each angle of a cube, and, as has been illustrated, these are the planes of the trapezohedron, fig. 19. The upper one of the planes 2.2 in there figures, when extended to meet the axes (as in fig. 19), intersects the vertical $c$ at its extremity, and the others, $a$ and $b$, at twice their lengths from the centre. Hence the expression for the plane is $1 c: 2 b: 2 a$. So, as will be found, the left hand plane $2-2$ on fig. 17, will have the expression $2 c: 1 b: 2 a$; and the right hand one, $2 c: 2 b: 1 a$. Further, the same ratio, by a change of the letters for tho semi-axes, will answer for all the planes of the trapezohedron.
In fig. 20 there are other three planes, 2 , on each of the angles of a cube, and these are the planes of the trisoctahedron in fig. 21. The lower one of the three on the upper front solid angle, would meet if extended, the extremities of the axes $a$ and $b$, while at would meet the vertical axis at twice its length from the centre. The expression $2 c: 1 b: 1 a$ indicates, therefore, the position of the plane. So also, $1 c: 1 b: 2 a$ and $1 c: 2 b: 1 a$ represent the positions of the other two planes adjoining; and corresponding expressions may be similarly obtained for all the planes of the trisoctahedron.

Again, in fig. 30 , of the cube with two planes on each edge, and in fig. 31, of the tetrahexahedron bounded by these same planes, the left of the two planes in the front vertical edge of fig. 30 (or the corresponding plane on fig. 31) is purallel to the vertical axis; its intersections with the lateral axes, $a$ and b, are at unequal distances from the centre, expressed by the ratio $2 b: 1 a$. This ratio for the plane adjoining on the right is $1 b: 2 a$. The position of the former is expressed by the ratio $i c: 2 b: 1 a$, and for the other by $i c: 1 b: 2 a$. Thus, for each of the planes of this tetrahexahedron the ratio between two axes is $1: 2$, while the plane is parallel to the third axis.

Again, in fig. 22, of the eube with six planes on each solid angle, and in the hezoctahedron in fig. 23, made up of such planes, each of the planes when extended so that it will meet one axis at once its length
from the centre, will meet the other axes at distances expressed by a constant ratio, and the expression for the lower right one of the six planes will be $3 c: \frac{3}{2} b: 1 a$. By a little study, the expressions for the other five adjoining planes can be obtained, and so also those for all the 48 planes of the solid.

In the isometrio system the axes $a, b, c$, are equal, so that in the general expressions for the planes these letters may be omitted; the expressions for the above mentioned forms thus become-

Cube (fig. 1), i: $1: i$.
Octahedron (fig. 2), 1:1:1.
Dodecahedron (fig. 3), $1: 1: i$.
Tetrahexahedron (fig. 5), $i: 1: 2$.
Trigonal trisoctahedron (fig. 6), 2:1:1.
Trapezohedron (fig. 4), 2:1:2. Hexoctahedrom (fig. 7), $3: 1: \frac{3}{4}$.
Looking again at fig. 17, representing the cube with planes of the trapezohedron, $2: 1: 2$, it will be perceived that there might be a trapezohedron having the ratios $1 \frac{1}{2}: 1: 1 \frac{1}{2}, \quad 3: 1: 3, \quad 4: 1: 4, \quad 5: 1: 5$, and others; and, in fact, such trapezohedrons occur among crystals. So also, besides the trigonal trisoctahedron 2:1:1 (fig. 21), there might be, and there in fact is, another corresponding to the expression 3:1:1; and still others are possible. And besides the hexoctahedron 3:1: $\frac{3}{2}$ (fig. 23), there are others having the ratios $4: 1: 2,4: 1: \frac{4}{3}$, $5: 1: 4$, and so on.

In the above ratios, the number for one of the lateral axes is always made a unit, since only a ratio is expressed; omitting this in the expression, the above general ratios become: for the cube, $i: i$; for the octahedron, $1: 1$; dodecahedron, $1: i$; trapezohedron, 2:2; tetrahexahedron, $i: 2$; trigonal-trisoctahedron, 2:1; and hexoctahedron, $3: \frac{3}{2}$. In the lettering of the figures these ratios are put on the planes, but with the second figure, or that referring to the vertical axis, first. Thus the lettering on the hexoctahedron (fig. 23), is $8-\frac{3}{2}$; on the trigonal trisoctahedron (fig. 21) is 2, the figure 1 being unnecessary; on the tetrahexahedron (fig. 31), $i-2$; on the trapezohedron (figs. 4 and 19), 2.2 ; on the dodecabedron (fig. 15), $i$; on the octahedron, 1 ; on the cube, $i-i$, in place of which $I I$ is used, the initial of hexahedron. In the printed page these symbols are written with a hyphen in order to avoid occasional ambiguity, thus $3-\frac{3}{2}, ~ i-2,2-2$, etc. Similarly, the ratios for all planes, whatever they are, may be written. The numbers are usually small, and never decimal fractions.

The angle between the planes $i$ - 2 (or $i: 1: 2$ ) and $O$, in fig. 30, page 21, may be easily calculated, and the same for any plane of the series $i-n(i: 1: n)$. Draw the right-angled triangle, $A D C$,
 as in the annexed figure, making the vertical side, $C D$, twice that of $A C$, the base; that is, give them the same ratio as in the axial ratio for the plane. If $A C=1, C D=2$. Then, by trigonometry, making $A O$ the radius, $1: R:: 2: \tan D A(1 ;$ or $1: R:: 2: \cot$ $A D C$. Whence $\tan D A C=\cot A D C=2$. By adding to $90^{\circ}$, the angle of the triangle obtained by working the equation, we have the inclination of the basal plane $O$, or the $O$ on the opposite side of the plane $i-2$, (faces of the cube) on the plane $i-2$. So in ell cases, whatever the value of $n$, that value equals the tangent of the basal angle of the triangle (or the cotangent of the angle at the vertex), and from this the inclination to the cubic faces is directly ob-
tained by adding $90^{\circ}$. If $n=1$, then the ratio is $1: 1$, as in $A C B$, and each angle equals $45^{\circ}$, giving $135^{\circ}$ for the inclination on either adjoining cubio face.

Again, if the angles of inclination have been obtained by measurement, the value of $n$ in any case may be found by reversing the above calculation; subtracting $90^{\circ}$ from the angle, then the tangent of this angle, or the cotangent of its supplement, will equal $n$, the tangents varying directly with the value of $n$.

In the case of planes of the $m: 1: 1$ series (including $1: 1: 1,2: 1:$ 1 , etc.), the tangents of the angle between a cubic face in the same zone and these planes, less $90^{\circ}$, varies with the value of $m$. In the case of the plane ( 1 ( $1: 1: 1$ ), the angle between it and the cubic face is $125^{\circ} 16^{\prime}$. Subtracting $90^{\prime \prime}$, we have $35^{\circ} 16^{\prime}$. Draw a right-angled triangle, $O D^{\prime} C^{\prime}$, with $35^{\circ} 10^{\prime}$ as its vertex angle. $B C^{\prime}$ has
 the value of $1 c$, or the semi-axis of the cube. Make $D C=2 B C$. Then, while the angle $O B C$ has the value of the inclination on the cubic tace less $90^{\prime \prime}$ for the plane 1:1:1,ODC has the same for the plane 2:1:1. Now, making $O C$ the radius, and taking it as unity, $B C$ is the tangent of $B O C$, or $\cot O B C^{\prime}$. So $D C=2 B C$ is the tangent of $D O C$, or cot ODC. By lengthening the side $C D$ ( $=2 B C$ or $2 c$ ) it may be made equal to $3 B C^{\prime}=3 c$, its value in the case of the plane $3: 1: 1$; or to $4 B C=4 c$, its value in the case of the plane $4: 1: 1 ;$ or $m B C=m c$ for any plane in the seriss $m: 1: 1$; and since in all there will be the eame relation between the vertical and the tangent of the angle at the base (or the cotangent of the angle at the vertex), it follows that the tangent varies with the value of $m_{0}$ Hence, knowing the value of the angle in the case of the form 1 ( $1: 1: 1$ ), the others are casily calculated from it.
$B C^{\prime}$ being a unit, the actual value of $O C$ is $\frac{1}{2} \sqrt{2}$, or $1 \sqrt{7}$, it being half the diagonal of a square, the sides of which are 1, and from this value the angle $35^{\prime} 16^{\prime}$ might be obtained for the angle O73C.

The above law (that for a plane of the $m: 1: 1$ series, the tangent of its inclination on a cubic face lying in the same zone, less $90^{\circ}$, varies with the value of $m$, and that it may be calculated for any plane $m: 1: 1$ from this inclination in the form $1: 1: 1$ ), holds also for planes in the series $m: 2: 1$, or $m: 3: 1$, or any $m: n: 1$. That is, given the inclination of 0 on $1: n: 1$, its tangent doubled will be that of $2: n: 1$, or trebled, that of $3: n: 1$, and so on; or halved, it will be
 1:2n:2.

These examples show some of the simpler methods of applying mathomatics in calculations under the isometric system. The values of tho axes are not required in them, because $a=b=c=1$.
3. Hemihedral Crystals - The forms of crystals described above are called holohedral forms, from the Greek for all and fuce, the number of planes being all that full symmetry requires. The cube has eight similar solid angles-similar, that is, in the enclosing planes and plane angles. Consequently the law of full symmetry requires that all should have the same
planes and the same number of planes; and this is the general law for all the forms. This is a consequence of the equality of the axes and their rectangular intersections.

But in some crystalline forms there are only half the number of planes which full symmetry requires. In fig. 39 a cube is represented with an octahedral plane on half, that is, four, of
39.

40.
41.

42.

the solid angles. A solid angle having such a plane is diagonally opposite to one without it. The same form is represented in fig. 40, only the cubic faces are the smallest; and in fig. 41 the simple form is shown which is made up of the four octahedral planes. It is a tetrahedron or regular three-sided pyranid. If the octahedral faces of fig. 39 had been on the other four of the solid angles of the cube, the tetrahedron made of those planes would have been that of fig. 42 instead of fig. 41.

Other hemihedral forms are represented in figs. 43 to 45 ; fig. 43 is a hemihedral form of the trapezohedron, fig. 4, p. 7;

fig. 44, hemihedral of the hexoctahedron, fig. 7, or a nemi-hexnctakedron. Fig. 45 is a combination of the tetrahedron (plane 1) and hemi-hexoctahedron.

In these forms figs. 41-44, no face has another parallel to it; and consequently they are called inclined hemihedrons.

Fig. 46 represents a cube with the planes of a tetrahexahedron, as already explained. In fig. 47, the cube has only one of the planes $i-2$ on each edge, and therefore only twelve in all;
and hence it affords an example of hemihedrism-a kind that is presented by many crystals of pyrite. Fig. 48 is the hemihe-

dral form resulting when these twelve planes $i-2$ are extended to the obliteration of the cubic faces; and fig. 49 is another,
 made of the other twelve of these planes. Again, in fig. 50, a cube is represented having only three out of the six planes of fig. 22, and this is another example of hemihedrism. These kinds differ from the inclined hemihedrons in having opposite parallel faces, and hence they are called parallel hemihedrons.
4. Internal Structure of Isometric Crystals, or Cleavage. The crystals of many isometric minerais have cleavage, or a greater or less capability of division in directions situated symmetrically with reference to the axes. The cleavage directions are parallel either to the faces of the cube, the octahedron, or the dodecabedron. In galenite (p. 145) there is easy cleavage in three directions parallel to the faces of the cube; in fluorite ( p . 208), in four directions parallel to the faces of the octahedron; in sphalerite (p.154), in six directions parallel to the faces of the dodecahedron. These cleavages are an important means of distinguishing the species.

The three cubic cleavages are precisely alike in the ease with which cleavage takes place, and in the kinds of surface obtained; and so is it with the four in the octahedral directions, and the six in the dodecahedral. Occasionally clearages of two of these systems occur in the same mineral ; that is, for example, parallel to both the faces of the cube and the octahedron; but when so, those of one system are much more distinct than those of the other, and cleavage surfaces in the two directions are quite unlike as to smoothness and lustre.
5. Irregularities of Isometric Crystals.-A cube has its faces precisely equal, and so it is with each of the forms represented
in figs. 2 to 7. This perfect symmetry is almost never found in actual crystals.

52.

53.


A cubic crystal has generally the form of a square prism (fig. 51 a stout one, fig. 52 another long and slender), or a rectangular prism (fig. 53). In such cases the crystal may still be known to be a cube; because, if so, the kind of surface and kind of lustre on the six faces will be precisely alike; and if there is cubic cleavage it will be exactly equal in facility in three rectangular directions; or if there is cleavage in four, or six, directions, it will be equal in degres in the four, or the six, directions, and have mutual inclinations corresponding with the angles of the octahedron or dodecahedron; and thus the crystal will show that it is isometric in system.

The same shortening or lengthening of the crystal often dis-

guises greatly the octahedron, dodecahedron, and other forms. This is illustrated in the following figures: Fig. 54 shows the
form of the regular octahedron; 55, an octahedron lengthened horizontally; 56, one shortened parallel to one of the pairs of faces; 57, one lengthened parallel to another pair, the ultimate result of which obliterates two of the faces, and places an acute solid angle in place of each. The solid is then six-sided, and has rhombic faces whose plane angles are $120^{\circ}$ and $60^{\circ}$. The following figures illustrate corresponding changes in the dodecahedron (fig. 58). In fig. 59 the dodeca-

hedron is lengthened vertically, making a square prism with foursided pyramidal terminations. In 60 , it is shortened vertically. In 61 the dodecahedron is lengthened obliquely in the direction of an octahedral axis, and in 62 it is shortened in the same direction, making six-sided prisms with trihedral terminations.

So again in the trapezohedron there are equally deceptive forms arising from elongations and shortenings in the same two directions.

These distortions change the relative sizes of planes, but not the values of angles. In crystals of the several forms represented in figs. 54 to 57 , the inclinations are the same as in the regular octahedron. There is the same constancy of angle in other distorted crystals.

Occasionally, as in the diamond, the planes of crystals are convex; and then, of course, the angles will differ from the true angle. It is important, in order to meet the difficulties in the way of recognizing isometric crystals, to have clearly in the mind the precise aspect of an equilateral triangle, which is the shape of a face of an octahedron; the form of the rhombic face of the dodecahedron; and the form of the trapezoidal face of a trapezohedron. With these distinctly remembered, isometric crystalline forms that are much obscured by distortion, or which show only two or three planes of the whole number, will often be easily recognized.

Crystals in this system, as well as in the others, often have their faces striated, or else rough with points. This is generally owing to a tendency in the forming crystal to make two different planes at the same time, or rather an oscillation between the condition necessary for making one plane and that for making another. Fig. 63 represents a cube of pyrite with striated faces. As the faces of a cube are equal, the striations are alike on all. It will be noted that the striations of adjoining faces aro at right
63.
 angles to one another. The little ridges of the striated surfaces are made up of planes of the pentagonal dodecahedron (fig. 49, p. 26), and they arise from an oscillation in the crystallizing conditions between that which, if acting alone, would make a cube, and that which would make this hemihedral dodecahedron. Again, in magnetite, oscillations between the octahedron and dodecahedron produce the striations in fig. 64.


Octahedral crystals of fluorite often occur with the faces made up of evenly projecting solid angles of a cube, giving
them rough instead of polished planes. This has arisen from oscillation between octahedral and cubic conditions.

In some cases crystals are filled out only along the diagonal planes. Fig. 65 represents a crystal of common salt of this kind, having pyramidal depressions in place of the regular faces. Octahedrons of gold sometimes occur with three-sided pyramidal depressions in place of the octahedral faces. Such forms sometimes result when crystals are eroded by any cause.

## II. DIMETRIC, or TETRAGONAL SYSTEM.

1. Descriptions of Forms.- In this system (1) the axes cross at right angles; (2) the vertical axis is either longer or shorter than the lateral; and (3) the lateral axes are equal.

The following figures represent some of the crystalline forms. They are very often attached by one extremity to the support-

ing rock and have perfect terminating planes only at the other. Śquare prisms, with or without pyramidal terminations, square octahedrons, eight-sided prisms, eight-sided pyramids, and especially combinations of these, are the common forms. Since the lateral axes are equal, the four lateral planes of the square prisms are alike in lustre and surface-markings. For the same reason the symmetry of the crystal is throughout by fours; that is, the number of similar pyramidal planes at the extremity is either four or eight; and they show that they are similar by
being exactly alike in inclination to the basal plane as well as alike in lustre.

There are two distinct square prisms. In one (fig. 10) the

axes connect the centres of the lateral faces. In the other (fig. 1:) they connect the centres of the lateral edges. In fig. 11 the two prisms are combined; the figure shows that the planes of one truncate the lateral edges of the other, the interfacial angle between adjoining planes being $135^{\circ}$. Figs. 2, 3, 4,7 , are of others having planes of both prisms. In fig. 13 one prism is represented within the other.

Fig. 14 represents an eight-sided prism, and fig. 15 a combination of a square prism (i-i) with an eight-sided prism (i-2).


A nother example of this is shown in fig. 4, and also in fig. 9, the planes $i-2$ in one, and $i-3$ in the other.

The basal plane in these prisms is an independent plane, because the vertical axis is not equal to the lateral, and hence it almost always differs in lustre and smoothness from the lateral.
like the square prisms, the square octahedrons are in two series, one set (fig. 16) having the lateral or basal edges parallel to the lateral axes, and these axes connecting the centres of opposite basal edges, and the other (fig. 17) having them diagonal to the axes, these axes connecting the apices of the opposite
solid angles, as in the isometric octahedron. There may be, on the same crystal, faces of several octahedrons of these two series, differing in having their planes inclined at different angles to

18.

19.

the basal plane. In figs. 5 and 7 there is one of these pyramids terminating the prism, and in figs. 6 and 8 the planes of two. In figs. 1 to 3 there are planes of the same octahedron, but combined with the basal plane $O$; and in fig. 4 there are planes of two, with $O$. In fig. 9 there are planes of the same octahedron, with planes of a square prism ( $i-i)$, and of an eight-sided prism (i-2). In fig. 18 there is the prism $i-i$ combined with two octahedrons, and the basal plane $O$; and in 19 the planes of one octahedron with the prism $I$.

Fig. 20 represents an eight-sided double pyramid, made of

equal planes, equally inclined to the base ; and fig. 21 , the same planes on the square prism $i-i$. The small planes, in pairs, on fig. 8, are of this kind. In fig. 22 the small planes $3-3$ of fig. 8 occur alone, without planes of the four-sided pyramids, aud therefore make the eight-sided pyramid, 3-3.

This solid of sixteen planes has the largest number of similar planes possible in the dimetric system, while the largest number in the isometric system (occurring in the hexoctahedron) is forty eight.
2. Positions of the Planes with reference to the Axes,-Lettering of planes. In the prism fig. 10, the lateral planes are parallel to the vertical axis and to one lateral axis, and meet the other lateral axis at its extremity. The expression for it is hence ( $c$ standing for the vertical axis and $a, b$ for the lateral) io : $i b: 1 a, i$, as before, standing for infinity and indicating parallelism. For the prism of fig. 12, the prismatic planes meet the two lateral axes at their extremities, and are parallel to the vertical, and hence the expression for them is $i c: 1 b: 1 a$. In the annexed figure the two bisecting lines, $a-a$ and $b-b$, represent the lateral axes; the line $8 t$ stands for a section of a lateral plane of the first of these prisms, it being parallel to one lateral axis and meeting the other at its extremity, and ab for that of the other, it mecting the two
23.
 at their extremities.

In the eight-sided prisms (figs. 14, 15), each of the lateral planes is parallel to the vertical axis, meets one of the lateral axes at its extremity, and would meet the other axis if it were prolonged to two or three or more times its length. The line ao, in fig. 23, has the position of one of the eight planes; it meets the axis $b$ at $o$, or twice its length from the centre ; and hence the expression for it would be ic: $2 b: 1 a$, or, since $b=a$, ic:2:1, which is a general expression for each of the eight planes. Again, $a_{p}$ has the position of one of the eight planes of another such prism ; and since $O p$ is three times the length of $O b$, the expression for the plane would be ic:3:1. So there may be other eightsided prisms; and, putting $n$ for any possible ratio, the expression ic : $n: 1$ is a general one for all eight-sided prisms in the dimetric system.

A plane of the octabedron of fig. 16 meets one lateral axis at its extremity, and is parallel to the other, and it meets the vertical axis $c$ at its extremity; its expression is consequently (dropping the letters $a$ and $b$, because these axes are equal) $1 c: i: 1$. Other octahedrons in the same vertical series may have the vertical axis longer or shorter than axis $c$; that is, there may be the planes $2 c: i: 1,3 c: i: 1$, $4 c: i: 1$, and so on; or $\frac{1}{2} c: i: 1, \frac{1}{4} c: i: 1$, and so on; or, using $m$ for any coefficient of $c$, the expression becomes general, mc:i:1. When $m=0$ the vertical axis is zero, and the plane is the basal plane 0 of the prism ; and when $m=$ infinity, the plane is ic : $i: 1$, or the vertical plane of the prism in the same series, $i i$, fig. 10.

The planes of the octahedron of fig. 17 meet two lateral axes at their extremities, and the vertical at its extremity, and the expression for the plane is hence $1 c: 1: 1$. Other octahedrons in this series will have the general expression $m c: 1: 1$, in whioh $m$ may have any value, not a decimal, greater or less than unity, as in the preceding case. When in this series $m=$ infinity, the plane is that of the prism ic $: 1: 1$, or that of fig. 12.

In the case of the double eight-sided pyramid (figs. 20, 21, 28), the planes meet the two lateral axes at minequal distances from the centre; and also meet the vertical axis. The expression may be
$20: 2: 1,40: 2: 1,50: 3: 1$, and so on; or, giving it a general form, $m o: n: 1$.

In the lettering of the planes on figures of dimetric orystals, the first number (as in the isometric and all the other systems) is the coefficient of the vertical axis, and the other is the ratio of the other two, and when this ratio is a unit it is omitted.

The expressions and the lettering for the planes are then as follows:

| For square prisms. . . . . . . 1. | $\begin{gathered} \text { Er.pressions. } \\ \text { io }: i: 1 \\ : 1: 1 \end{gathered}$ | Lettering. $i-i$ $i$ or $I$. |
| :---: | :---: | :---: |
| For eight-sided prisms..... | ic : $n: 1$ | i-n |
| For octahedrons........... $\left\{\right.$1. <br> . | $m c: i: 1$ $m c: 1: 1$ | $\begin{aligned} & m-i \\ & m \end{aligned}$ |
| For double eight-sided pyramids, | $m c: n: 1$ | $m \cdot n$ |

The symbols are written without a hyphen on the figures of crystals. On figure 14, the plane $i-n$ is that particular $i-n$ in which $n=2$, or $i-2$. ln fig. 21 the planes of the double eight-sided pyramid, $n-n$, bave $m=1$ and $u=3$ (the expression being $1: 2: 1$ ), and hence it is lettered 1-2. In fig. 8 and in fig. 22 it is the one in which $m=3$ and $n=3$ (the expression being $3: 3: 1$ ), and hence the lettering $3-3$.

The length of the vertical axis $c$ may be calculated as follows, provided the crystal affords the required angles:

Suppose, in the form fig. 18, the inclination of $O$ on plane $1-i$ to have been found to be $130^{\circ}$, or of $i-i$ on the same plane, $140^{\circ}$ (one follows from the other, since the sum of the two, as has been explained, is necessarily $270^{\circ}$ ). Subtracting $90^{\circ}$, we have $40^{\circ}$ for the inclination of the plaue on the vertical axis $c$, or $50{ }^{\prime}$ for the same on the lateral axis $a$, or the basal section. In the right-angled triangle, $O B C$, the angle $O B C$ equals $40^{\circ}$. If $O C$ be taken as $a=1$, then $B C$ will
 be the length of the vertioal axis $c$; and its value may be obtained by the equation $\cot 40^{\circ}=B C$, or $\tan 50^{\circ}=B C^{\circ}$.

On fig. 18 there is a second octahedral plane, lettered $\frac{1}{3}-i$, and it might be asked, Why take one plane rather than the other for this calculation? The determination on this point is more or less arbitrary. It is usual to assume that plane as the unit plane in one or the other series of octahedrons (fig. 16 or fig. 17) which is of most common occurrence, or that which will give the simplest symbols to the crystalline forms of a species; or that which will make the vertical axis nearest to unity; or that which corresponds to a cleavage direction.

The value of the vertical axis having been thus determined from $1-i$, the same may be determined in like manner for $\frac{1}{2}-i$ in the same figure (fig. 18). The result would be a value just half that of $B C$. Or if there were a plane $2 i$, the value obtained would be twice $B C$, or $B D$ in fig. 24; the angle $O D C+90^{\circ}$ would equal the inclination of $O$ on $2-i$. So for other planes in the same vertical zone, as $3-i$, $4-i$, or any plane $m-i$.

If there were present several planes of the series $m-i$, and their inoli-
nations to the basal plane $O$ were known, then, after subtracting from the values $90^{\circ}$, the ootangents of the angles obtained, or the tangents of their complements, will equal $m$ in each case; that is, the tangents (or cotangents) will vary directly with the value of $m$. The logarithm of the tangent for the plane $1-i$, added to the logarithm of 2 , will equal the logarithm of the tangent for the plane $2-i$, and so on.

The law of the tangents for this vertical zone $m-i$ holds for the planes of all possible vertical zones in the dimetric system. Further, if the square prism were laid on its side so that one of the lateral planes became the base, and if zones of planes are present on it that are vertical with reference to this assumed base, the law of the tangents still holds, with only this difference to be noted, that then one of the lateral axes is the vertical. It holds also for the trimetric system, no matter which of the diametral planes is taken for the base, since all the axial intersections are rectangular. It holds for the monoclinic system for the zone of planes that lies between the axes $c$ and $b$ and that between the axes $\alpha$ and $b$, since these axes meet at right angles, but not for that between $c$ and $a$, the angle of intersection here being oblique. It holds for all vertical zones in the hexagonal system, since the basal plane in this system is at right angles to the vertical axis. But it is of no use in the triclinuic system, in which all the axial intersections are oblique.

The value of the vertical axis $c$ may be calculated also from the inclination of 0 on 1 , or of $I$ on 1 . See fig. 2, and compare it with fig. 17. If the angle $I$ on 1 equals $140^{\circ}$, then, after subtracting $90^{\circ}$, we have $50^{\circ}$ for the basal angle in the triangle $O C B$, fig. 24 ; or for half the interfacial angle over a basal edge-edge $Z$-in fig. 17. The value of 0 may then be calculated by means of tho formula

$$
c=\tan \frac{1}{2} Z_{V} \frac{1}{2}
$$

by substituting $50^{\circ}$ for $\frac{1}{2} Z$ and working the equation.
For any octahedron in the series $m$, the formula is

$$
m c=\tan \frac{1}{2} Z_{v \frac{1}{2}}
$$

$Z$ being the angle over the basal edge of that octahedron. If $m=2$, then $c=\frac{1}{2}\left(\tan \frac{1}{2} Z \sqrt{\frac{1}{2}}\right)$. Further, $m=\left(\tan \frac{1}{2} Z v \frac{1}{2}\right) \div c$.

The interfacial angle over the terminal edge of any octahedron $m$ may be obtained, if the value of $c$ is known, by the formulas

$$
m c=\cot \epsilon \quad \cos \epsilon=\cot \frac{1}{2} X
$$

$X$ being the desired angle (fig. 17). The same for any octahedron $m-6$ may be calculated from the formulas

$$
m c=\cot \epsilon \quad \cos \epsilon=\cos \frac{1}{2} Y_{v} 2
$$

$Y$ being the desired angle (fig. 16).
For other methods of calculation reference may be made to the "Text Book of Mineralogy," or to some other work treating of mathematical crystallography.
3. Hemihedral Forms.-Among the few hemihedral forms under the dimetric system there is a tetrahedron, called a sphen-
oid (figs. 25 or 26 ), and also forms in which only half of the sixteen planes of the double eight-sided pyramid, or half the eight planes of an eight-sided prism-those alternate in position
25.

26.

27.

28.

-are present (figs. 27, 28). In fig. 27 the absent planes are those of half the pairs of planes; and in fig. 28 they include one of each of the pairs, as will be seen on comparing these figures with fig. 21.
4. Cleavage.-In this system cleavage may occur parallel to the sides of either of the square prisms; parallel to the basal plane; parallel to the faces of a square octahedron; or in two of these directions at the same time. Cleavage parallel to the base and that parallel to a prism are never equal, so that such prisms need not be confounded with distorted cubes.
5. Irregularities in Crystals.-The square prisms are very often rectangular instead of square, and so with the octahedrons. But, as elsewhere among crystals, the angles remain constant. When forms are thus distorted, the four prismatic planes will have like lustre and surface markings, and thus show that the faces are normally equal and the lateral axes therefore equal. If the plane truncating the edge of a prism makes an angle of precisely $135^{\circ}$ with the faces of the prism, this is proof that the prism is square, or that the lateral axes are equal, since the angle between a diagonal of a square and one of its sides is $45^{\circ}$, and $135^{\circ}$ is the supplement of $45^{\circ}$.
6. Distinctions. -The dimetric prisms have the base different in lustre from the sides, and planes on the basal edges different in angle from those on the lateral, and thus they differ from isometric forms. The lateral edges may be truncated, and the new plane will have an angle of $135^{\circ}$ with those of the prism, in which they differ from trimetric forms, while like isometric. The extremities of the prism, if it have any planes besides the basal, will have them in fours or eights, each of the four, or of the eight, inclined to the base at the same angle. When there is any cleavage parallel to the vertical axis, it is alike
in two directions at right angles with one another. The lateral planes of either square prism are alike in lustre and markings.

## III. TRIMETRIO, OR ORTHORHOMBIC SYSTEM.

1. Descriptions of Forms. -The crystals under the trimetric system vary from rectangular to rhombic prisms and rhombic octahedrons, and include various combinations of such forms. Figs. 1 to 7 are a few of those of the species burite, and figs. 8 to 10 of crystals of sulphur.


Fig. 11 represents a rectangular prism (diametral prism), and fig. 12 a rhombic prism, each with the axes. The axes connect the centres of the opposite planes in the former ; but in the latter the lateral axes connect the centres of the opposite edges. Of the two lateral axes the longer is called the macrodiagonal, and the shorter the brachydiagonal. The vertical section containing the former is the macrodiagonal section and that containing the latter, the brachydiagonal section.

In the rectangular prism, fig. 11, only opposite planes are alike, because the three axes are unequal. Of these planes, that opposite to the larger lateral axis is called the mecropinacoid, and that opposite the shorter the brachypinacoid (from the Greak for long and short, and a word signifying board or table). Each
pair-that is, one of these planes and its opposite-is called a hemiprism.

In the rhombic prism, fig. 12, the four lateral planes are similar planes. But of the four lateral edges of the prism two
11.
12.


are obtuse and two acute. Fig. 13 represents a combination of the rectangular and rhombic prisms, and illustrates the relations of their planes. Other rhombic prisms parallel to the vertical axis occur, differing in interfacial angles, that is, in the ratio of the lateral axes.

Bosides vertical rhombic prisms, there are also horizontal prisms parallel to each lateral axis, $a$ and $b$. In fig. 2 the narrow planes in front (lettered $\frac{1}{2} \bar{q}$ ) are planes of a rhombic prism parallel to the longer of the lateral axes, and those to the right (17) are planes of another parallel to the shorter lateral axis. In fig. 6 the planes are those of these two horizontal prisms. Such prisms are called also domes, because they have the form of the roof of a house (domus in Latin meaning houss). In fig. 3 these same two domes occur, and also the planes (lettered $I$ ) of a vertical rhombic prism. Of these domes there may be many both in the macrodiagonal and the brachydiagonal series, differing in angle (or in ratio of the two intersected axes). Those parallel to the longer lateral axis, or the macrodiagonal, are called macrodomes ; and those parallel to the shorter, or brachydiagonal, are called brachydomes.

A rhombic octahedron, lettered 1, is shown in fig. 8 ; a combination of two, lettered 1 and $\frac{1}{3}$, in tig. 9 ; and a combination of four, lettered $1, \frac{7}{2}, \frac{1}{8}, \frac{1}{f}$, in fig. 10 . This last figure contains also the planes $I$, or those of a vertical rhombic prism; the planes 1-i, or those of a dome parallel to the longer lateral axis; the planes $1-2$, or those of a dome parallel to the shorter lateral axis; the plane $O$, or the basal plane; the plane $i-\breve{\imath}$, or the brachypinacoid; and also a rhombic octahedron lettered 1-گ.
2. Positions of Planes. Lettering of Crystals.-The notation is, in a general way, like that of the dimetric system, but with differsnces made necessary by the inequality of the lateral axes. The letters
for the three are written $c: \bar{b}: \breve{a} ; \bar{b}$ being the longer lateral and $\check{a}$ the shorter lateral. In place of the square prism of the dimetric system, $i-i$, there are the hemiprisms $i \cdot \bar{i}$ and $i-\bar{\eta}$, or the macropinacoid and brachypinacoid, having the expressions $i c: i \hat{b}: 1 \ddot{a}$ and $i c: \hat{b} \hat{b}: i \ddot{a}$. The form $I$ is the rhombic prism, having the expression ic :1E: 10 , corresponding to the square prism $I$ in the dimetric system. The planes $i-\bar{i}$ or $i-n$ are other rhombic vertical prisms, the former corresponding to ic $: n \bar{b}: 1 \check{a}$, the other to $i c: 1 \bar{b}: n \check{a}$. If $\mathcal{z}=2$, the plane is lettered either $i-\overline{2}$ or $i-\bar{z}$. The plane 1-3 has the expression $1 c: 1 \bar{b}: 3 \check{u}$. $m-\bar{n}$ and $n-\check{h}$ comprise all possible rhombic prisins and octahedrons, and correspond to the expressions $m c: n \bar{b}: 1 \breve{u}$ and $m c: 1 \bar{b}: n a ̆$. When $m=$ infinity they become $\dot{z-n}$ and $i-n$, or expressions for vertioal rhombic prisms; when $n=$ infinity they become $m-i$ and $m-\imath$, or expressions for macrodomes and brachydomes.

The question which of the three axes should be taken as the vertical axis is often decided by reference simply to mathematical convenience. Sometimes the crystals are prominently prosmatic only in one direction, as in topaz, and then the axis in this direction is made the vertical. In many cases a cleavage rhombic prism, when there is one, is made the vertical, but exceptions to this are numerous. There is also no general rule for deciding which octahedron should be taken for the unit octahedron. But however decided, the axial relations for the planes will remain essentially the same. In fig. 10, had the plane lettered $\frac{1}{2}$ been mule the plane 1 , then the series, instead of being as it is in the figure, $1, \frac{1}{2}, \frac{1}{3}, \frac{1}{6}$, would have been $2,1, \frac{2}{3}, \frac{8}{8}$, in which the mutual axial relations are the same.

The relative values of the axes in the trimetric system may be calculated in the same way as that of the vertical axis in the dimetric system, explained on page 34. The law of the tangents, as stated on page 35 , holds for this system.
3. Hemihedral Forms.-Hemihedral forms are not common in this system. Some of those so considered have been proved to owe their apparent hemihedrism to their being of the monoclinic system, as in the case of datolite and two species of the chondrodite group. In a few kinds, as, for example, calamine, one extremity of a crystal differs in its planes from the other. Such forms are termod hemimorphic, from the Greek for half and form. They become polar electric when heated, that is, are pyroelectric, showing that this hemimorphism is connected with polarity in the crystal.
4. Cleavage.-Cleavage may take place in the direction of either of the diametral planes (that is, cither face of the rectangular prism) ; but it will be different in facility and in the surface afforded for each. In anhydrite, however, the difference is very small. Cleavage may also occur in the direction of the planes of a rhombic prism, either alone or in connection with cleavage in other directions. It also sometimes occurs, as in sulphur, parallel to the faces of a rhombic octahedron.
5. Irregularities in Crystals. -The crystals almost never corin their diametral dimensions with the calculated axial dimensions. They are always lengthened, widened, shortened, or narrowed abnormally, but without affecting the angles. Exapples of diversity in this kind of distortion are given in figs. 1 to 7 , of barite.
6. Distinctions. -In the trimetric system the angle $135^{\circ}$ does not occur, because the three axes are unequal. There are paramids of four similar planes in the system, but never of eight; and the angles over the terminal edges of the pyramids are never equal as they are in the dimetric system. The rectangular octahedron of the trimetric system is made up of two horizontal prisms, as shown in fig. 6, and is therefore not a simple form ; and it differs from the octahedron of the dimetric symtom corresponding to it (fig. 16, p. 32) in having the angles over the basal edges of two values.

## Iv. MONOCLINIC SYSTEM.

1. Descriptions of Forms. -In this system the three axes are unequal, as in the trimetric system; but one of the axial intersections is oblique, that between the axis $a$ and the vertical axis c. The following examples of its crystalline forms, figs. 1 to 6 , show the effect of this obliquity. On account of it the front or back planes above and below the middle in those figures differ, and the anterior and postericr prismatic planes are onequally inclined to a basal plane.


The axes and their relations are illustrated in figs. 7 and 8. Fig. 7 represents an oblique rectangular prism, and fig. 8 an oblique rhombic. The former is the diametral prism, like the rectangular of the trimetric system. The axes connect the centres of the opposite faces, and the planes are of three
distinct kinds, being parallel to unlike axes and diametral sections. In the latter, as in the trimetric rhombic prism, the lateral axes connect the centres of the opposite sides. Moreover, this rhombic prism may be reduced to the rectangular by the removal of its edges by planes parallel to the lateral axes.


The axis $a$, or the inclined lateral axis (inclined at an oblique angle to the vertical axis $c$ ), is called the clinodiagonal; and the axis $b$, which is not inclined, the orthodiagonal (from the Greek for right, or rectangular). The vertical section through the former is called the clinodiagonal section ; it is parallel to the plane $i-i$ (fig. 1-6). The vertical section through the latter is

the orthodiagonal section; it is parallel to planes $i-i$. Owing to the oblique angle between $a$ and $c$, the planes above $a$ differ in their relations to the axes from those below, and hence comes the difference in the angle they make with the basal plane.

The halves of a crystal either side of the clinodiagonal section -the vertical section through $a$ and $c$-are alike in all planes and angles. Another important fact is this: that the plane $i-i$, or that parallel to the clinodiagonal section, is at right angles not only to $O$ and $i-i$, but to all planes in the zone of $O$ and $i-i$;
that is, in the clinodiagonal zone; and this is a consequence of the right angle which axis $b$ makes with both axis $c$ and axis a. The plane $i-i$ is called the orthopinacoid, it being parallel to the orthodiagonal; and the plane $i-\hat{\imath}$, the clinopinacoid, it being parallel to the clinodiagonal.

Vertical rhombic prisms have the same relations to the lateral exes as in the trimetric system. Domes, or horizontal rhombic prisms, occur in the orthodiagonal zone, because the vertical axis $c$ and the orthodiagonal $b$ make right angles with one another. In fig. 6 the planes $1-i$, $2-i$ belong to two such domes. They are called clinodomes, because parallel to the clinodiagonal.

In the clinodiagonal zone, on the contrary, the planes above and below the basal plane differ, as already stated, and hence there can be no orthodomes; they are hemiorthodomes. Thus, in fig. $6, \frac{1}{2}-i, 1-i$ are planes of hemiorthodomes above $i-i$, and $-\frac{1}{2}-i$ is a plane of another of different angle below $i-i$. The plane, and its diagonally opposite, make the hemiorthodome.

The octahedral planes above the plane of the lateral axes also differ from those below. Thus, in figs. 5 and 6 , the planes 1,1 are, in their inclinations, different planes from the planes -1, -1 ; so in all cases. Thus there can be no monoclinic octahedrons -only hemioctahedrons. An oblique octahedron is made up of two sets of planes; that is, planes of two hemioctahedrons. Such an octahedron may be modelled and figured, but it will consist of two sets of planes: one set including the two above the basal section in front and their diagonally opposites behind

(fig. 9), and the other set including the two below the basal section and their diagonally opposites (fig. 10).

A hemioctahedron, since it consists of only four planes, is really an obliquely placed rhombic prism, and very frequently they are so lengthened as to be actual prisms.
2. Positions of Planes. Lettering of Crystals.-On account of the obliquity of the orystals, the planes above and below the basal section require a distinguishing mark in their lettering, as well as in the mathematical expressions for them. One set is made minus and the other plus. The plus sign is omitted in the lettering. In fig. 7 there are above the basal section (or above $i-i$ ) the planes $1-i, \frac{1}{2}-i, 1, \frac{1}{2}$, but below it, $-\frac{1}{2}-i,-1$. The plus planes are those opposite the acute intersection of the basal and orthodiagonal sections, and the minus those opposite the obtuse. No signs are needed for planes of the clinodiagonal section, since they are alike both above and below the basal section.

The distinction of longer and shorter lateral axis is not available in this system, since either may be the clinodiagonal. The distinction of clinodiagonal and orthodiagonal planes is indicated by a grave accent over the number or letters referring to the clinodiagonal. The lettering for the clinodomes on fig. 6 is $1-i, 2-i$-the $i$ (initial of infinite, with the accent) signifying parallelism to the clinodiagonal. The hemioctahedrons, 1, 2, etc., need no such mark, as the expression for them is $1 c: 1 b: 1 d, 2 c: 1 b: 1 d$, the planes having a unit ratio for $a$ and $b$. But the plane $2-2$, in fig. 5 , requires it, its expression being $2 c: 1 b: 2 d$; the fact that the last 2 refers to the clinodiagonal is indicated by the accent. If it referred to the orthodiagonal, that is, if the expression for the plane were $2 c: 2 b: 1 d$, it would be written $2-2$ without the accent.
3. Cleavage.-Cleavage may be basal, or parallel to either of the other diametral sections, or parallel to a vertical rhombic prism, or to the planes of a hemioctahedron; or to the planes of a clinodome, or to that of a hemiorthodome. If occurring in two or more directions in any species it is always different in degree in each different direction, as in all the other systems.
4. Irregularities.-Crystals of this system may be elongated abnormally in the direction of either axis, and any diagonal. The hemiorthodomes may be in aspect the bases of prisms, and the hemioctahedrons the sides of prisms. Which plane in the zone of hemiorthodomes should be made the base, and which in the series of hemioctahedrons should be assumed as the fundamental prism determining the direction of the vertical axis, is often decided differently by different crystallographers. Convenience of mathematical calculation is often the principal point referred to in order to reach a conclusion.

## V. TRICLINIC SYSTEM.

1. Descriptions of Forms.-In the triclimic system the three axes are unequal and their three intersections are oblique, and consequently there are never more than two planes of a kind;
that is, planes having the same inclinations to either diametral tion. The following are examples:


The difference in angle from monoclinic forms is often very small. This is true in the Feldspar family. Fig. 2, of the feldspar called anorthite, is very similar in general form to fig. 4, of orthoclase, which is monoclinic. This is still more strikingly seen on comparing fig. 4 with fig. 5 , representing a crystal of oligoclase, another one of the triclinic feldspars. The


ORTHOCLASE.

oligoclase.
planes on the two are the same with one exception; but there is this difference, that in orthoclase, as in all monoclinic crystals, the angle between the planes $O$ and $i-\bar{z}$ (the two directions
of cleavage) is $90^{\circ}$; and in oligoclase and the other triclinic feldspars it is $3^{\circ}$ to $5^{\circ}$ from $90^{\circ}$, being in oligoclase $93^{\circ} 50^{\prime}$, and in anorthite $94^{\circ} 10^{\prime}$. This difference in angle involves oblique intersections between the axes $b$ and $c$, and $c$ and $a$, which are rectangular in monoclinic forms. There is a similarly close relation between the triclinic form of rhodonite and that of pyroxene, and a resemblance also in composition.

The diametral prism in this system is similar to fig. 7 on page 41, under the monoclinic system, but differs in having the planes all rhomboidal instead of part rectangular. The form corresponding to the oblique rhombic prism of the monoclinic system (fig. 8, p. 41) also has rhomboidal instead of rhombic planes; moreover, the two prismatic planes have unequal inclinations to the vertical diametral section, and are therefore dissimilar planes. The prism, consequently, is made of two hemiprisms, and the basal plane is another, making in all three hemiprisms.
2. Cleavage.-Cleavage takes place independently in different diametral or diagonal directions. In the triclinic feldspars it conforms to the directions in orthoclase, with only the exception arising from the obliquity above explained.

## VI. HEXAGONAL SYSTEM.

This system is distinguished from the others by the character of its symmetry-the number of planes of a kind around the vertical axis being a multiple of 3 . The number of lateral axes is hence 3. It is related to the dimetric system in having the lateral axes at right angles to the vertical and equal, and is hence like it also in the optical characters of its crystals. Its hexagonal prismatic form approaches trimetric crystals in the obtuse angle ( $120^{\circ}$ ) of the prism, some trimetric crystals baving an angle of nearly $120^{\circ}$.

Under this system there are two sections:

1. The Hexagonal section, in which the number of planes of a kind around each vertical axis above or below the basal section is 6 or 12.
2. The Rhombohedral section, in which the number of planes of a kind around each half of the vertical axis, above or below the basal section, is 3 or 6 ; and, in addition, the planes above are alternate in position with those below. The forms are mathematically hemihedral to the hexagonal, but not so in their real nature.

## I. HEXAGONAI SECTION,

1. Description of Forms.-Figs. 1 to 3 represent some of the forms under this section. Figs. 2 and 3 show only one ex-

tremity; and such crystals are seldom perfect at both. All exhibit well the symmetry by sixes which characterizes this section of the hexagonal system.


Under this system there are two hexagonal prisms and a number of occurring twelve-sided prisms. Fig. 4 represents one of the hexagonal prisms, with its axes-the three lateral connecting the centres of the opposite edges. The lateral angles of the prism are $120^{\circ}$. If the lateral edges of this prism are truncated, as in the figure of apatite (fig. 3), the truncating planes, $i-2$, are the lateral faces of another similar hexagonal prism, in which, as the relations of the two show, the
lateral axes connect the centres of the opposite lateral faces. This prism is represented in fig. 5.

The lateral edges of the hexagonal prisms occur sometimes with two similar planes on each edge, and these planes, when extended to the obliteration of the hexagonal prism, make a twelve-sided prism. These two planes are seen in fig. 8, along with the planes $I$ of the hexagonal prism, and 1 of a double sixsided pyramid, besides the basal plane 0 .

Double pyramids. The double
 pyramids are of three kinds: (1) A series of six-sided, whose planes belong to the same vertical zone with the planes $I$. The planes of two such pyramids (lettered 1, 2) are shown in figs. I and 2, three of them in fig. 3 (lettered $\frac{1}{2}, 1,2$ ), and one in fig. 7, and one such double pyramid, without combination with other planes, in fig. 6. (2) A series of six-sided double pyramids, whose planes are in the same vertical zone with $i-2$, examples of which occur on fig. 2 (plane 2-2)-on fig. 3 (planes 1-2, 2-2, 4-2). The form of this double pyramid is like that represented in fig. 6, but the lateral axes connect the centres of the basal edges. The double sixsided pyramid is sometimes called a quartzoid, because it occurs in quartz. (3) Twelve-sided double pyramids. Two planes of such a pyramid are shown on a hexagonal prism in fig. 9, also in

11.

fig. 2 (the planes $3-\frac{3}{2}$ ), and the simple form consisting of such planes in fig. 10-a form called a berylloid, as the planes are common in beryl. In fig. 11 the planes 1 belong to a double six-sided pyramid; and those next below (of which three are lettered $W^{W}$ ) to a double twelve-sided pyramid.
2. Lettering of Crystals.-The prism of fig. 5 is lettered $i-2$, because it is parallel to the vertical axis, and has the ratio of $1: 2$ between two lateral axes. This is shown in the annexed figure, which represents the hexagonal outline of the prism $i-2$ circumscribing that of the prism $I$. The plane $i-2$ is produced to meet axis $a$, which it does when $a$ is extended to twice its length; whence the ratio for the axes $a, \alpha^{\prime}$, is $1: 2$.

The numbers 1, 2, on the double hexagonal pyramids in fig. 1 indicate the relative lengths of the vertical axis of the two pyramids, they having the same 1:1 ratio of the lateral axes; and so in figs. 2, 3, and others.
The lettering on the pyramids of the other series in fig. 3, 1-2, 2-2, 4-2, indicates, by the second figure, that the planes are in the same vertical zone with the prismatic plane $i-2$, and by the first figure the relative lengths of the vertical axes.

In the twelve-sided prisms such ratios as $i-\frac{3}{2}, i-\frac{5}{3}, i-\frac{4}{4}$ occur. The fraction in any case expresses the ratio of the lateral axes for the particular planes. The double twelve-sided pyramids have the ratios $3-\frac{5}{2}$ (fig. 2), $4-\frac{4}{3}$, and others. Both in these forms and the twelve-sided prisms, the second figure in the lettering, expressing the ratio of the lateral axes, has necessarily a value between 1 and 2.
3. Hemihedral Forms.-Fig. 13 represents a crystal of apatite in which there are two sets of planes, $o\left(=3-\frac{3}{2}\right)$ and $o^{\prime}\left(=4-\frac{4}{3}\right)$ which are hemihedral, only half of the full number of each o existing instead of all. This kind of hemihedrism consists in the suppression of an alternate half of the planes in each pyramid of the double twelve-sided pyramid (fig. 10), and in the suppressed planes of the upper pyramid being here directly over those suppressed in the lower pyramid. If the student will shade over half the planes alternately of the two pyramids, putting the shaded planes above directly over
13.
 those below, he will understand the nature of the hemihedrism. In some hemihedral forms the suppressed planes of the upper pyramid alternate with those of the lower; but this kind occurs only in the rhombohedral section of the hexagonal system.
4. Cleavage.-Cleavage is usually basal, or parallel to a six-
sided pyramid. Sometimes there are traces of cleavage parallel to the faces of a six-sided pyramid.

## 5. Irregularities of Crystals.-

 Distortions sometimes disguise greatly the real forms of hexagonal crystals by enlarging some planes at the expense of others. This is illustrated in fig. 14, representing the actual form presented by a crystal having the planes shown in fig. 13. Whenever in a prism the prismatic angle is exactly $120^{\circ}$ or $150^{\circ}$, the form is alnost always of the hexagonal system.14. 



## 2. RHOMBOHEDRAT SECTION.

1. Descriptions of Forms.-The following figures, 1 to 17, represent rhombohedral crystals, and all are of one mineral, calcite. They show that the planes of either end of the crystal are in threes, or multiples of threes, and that those above are alternate in position with those below. There is one exception
2. 


2.

5.
3.

8.

9.

10.

11.

12.

13.


FIGURES OF CRYSTALS OF CALCITE.
to this remark, that of the horizontal or basal plaue $O$, in figs. $8,11,13$. The simple rhombohedral forms include:

1. Rhombohedrons, figs. 1 to 6. These forms are included nin- six equal planes, like the cube, but these planes are
rhombic ; and instead of having twelve rectangular edges, they have six obtuse edges and six acute.
2. Scalenohedrons, fig. 7. Scalenohedrons are really double six-sided pyramids; but the six equal faces of each extremity

figures of crystals of calcite.
of the crystals are scalene triangles, and are arranged in three pairs; moreover the pairs above alternate with the pairs below; the edges in which the pairs above and below meet-that is the basal edges-make a zig-zag around the crystal.
3. Hexagonal prisms, $I$, fig. 8. These are regular hexagonal prisms, having angles between their faces of $120^{\circ}$.

A rhombohedron has two of its solid augles made up of three equal plane angles. When in position the apex of one of these solid angles is directly over that of the other, as in figs. 1 to 6, and also in fig. 18, and the line connecting the apices of these angles (fig. 18) is called the vertical axis. In this position
18.


19

20.

the rhombohedron has six terminal edges, three above and three below, and six lateral edges. As these lateral edges are symmetrically situated around the centre of the crystal, the three lines connecting the centres of opposite basal edges will cross at angles of $60^{\circ}$. These lines are the lateral axes of the
rhombohedron, and they are at right angles to the vertical axis. It is stated on page 45 that rhombohedral forms are, from a mathematical point of view, hemihedral under the hexagonal system. The rhombohedron, which may be considered a double three-sided pyramid, is hemihedral to the double six-sided pyramid. Fig. 19, representing the latter form, has its alternate faces shaded; suppressing the faces shaded the form would be that of Gig. 18; and suppressing, instead of these, the faces not shaded, the form would be that of another rhombohedron, differing only in position. The two are distinguished as plus and minus rhombohedrons. They are combined in figs. 20, 21, forms of quartz. Rhombohedrons vary greatly in the length of the vertical axis with reference to the lateral. Figs. 1, 2, 3, and 18 represent crystals with the vertical axis short, and figs. 4, 5, 6 others with a long vertical axis. In the former the terminal edges are obtuse and the lateral acute, and the latter have the terminal edges acute and the lateral obtuse; the former are called obtuse rhombohedrons, and the latter acute.

The cube placed on one solid angle, with the diagonal between it and the opposite solid angle vertical, is, in fact, a rhombohedron intermediate between obtuse and acute rhombohedronsthe edges that are the terminal in this position, and those that are the lateral, being alike rectangular edges. Fig. 3 has nearly the form of a cube in this position.

The relation of one series of scalenohedrons to the rhombohedron is illustrated in fig. 22. This figure represents a rhombohedron with the lateral edges bevelled. These bevelling planes are those of a scalenohedron, and the outer lines of the same figure show the form of that scalenohodron which is obtained when the bevelment is continued to the obliteration of the rhombohedral planes. Fig. 14 represents this scalenohedron with the rhombohedral planes much reduced in size. Other scalenohedrons result when the terminal edges are bevelled, and still others from pairs of planes on the angles of a rhombohodron.

The scalenohedron is hemihedral to the twelve-sided double pyramid (fig. 23).

In the hexagonal system the three vertical axial planes divide the space about the vertical axis into six sectors (fig. 12, p. 48).


The twelve-sided double pyramid has in each pyramid a pair of faces for each sector; that is, six pairs for each pyramid. If now the three alternato of these pairs, and those in the upper pyramid alternate with those of the lower (the shaded in fig. 23), were enlarged to the obliteration of the rest of the planes, the
 resulting form would be a scalenohedron-a solid with three pairs of planes to each pyramid instead of six. Such is the mathematical relation of the scalenohedron to the twelvesided double pyramid. If the faces enlarged were those not shaded in fig. 23, another scalenohedron would be obtained which would be the minus scalenohedron, if the other were designated the plus.

Fig. 8 shows the relations of a rhombohedron to a hexagonal prism. The planes $R$ replace three of the terminal edges at each base of the prism, and those above alternate with those below. The extension of the planes $R$ to the obliteration of those of the prismatic planes, $I$, and that of the basal plane $O$, would produce the rhombohedron of fig. 1. Figs. 9 and 10 represent the same prism, but with terminations made by the rhombohedron of fig. 2.

By comparing the above figures, and noting that the planes of similar forms are lettered alike, the combinations in the figures will be understood. Fig. 16 is a combination of the planes of the fundamental rhombohedron $R$, with those of another rhombohedron 4, and of two scalenohedrons $1^{5}$ and $1^{5}$. Fig. 17 contains the planes of the rhombohedron $-\frac{1}{2}$, with those of the scalenohedron $1^{3}$, and those of the prism $i$. These figures, and figs. 14, 22, have the fundamental rhombohedron revolved $60^{\circ}$ from the position in fig. 1, so that two planes $R$ are in view above instead of the one in that figure.
2. Lettering of Figures.-Figs. 1 to 6, representing rhombohedrons of the species calcite, are lettered with numerals, excepting fig. 1. In fig. 1 the letter $R$ stands for the numeral 1, and the numerals on the others represent the relative lengths of their vertical axes, the lateral being equal. In fig. 4 the vertical axis is twice that in fig. 1 ; in fig. 6 thirteen times; and in fig. 15 the planes lettered 16 are those of a rhombohedron whose vertical axis is sixteen times that of fig. 1. The rhombohedrons of figs. $1,5,6$, and 15 are plus rhombohedrons; that is, they are in the same vertical series; while 2 and 3 are minus rhombohedrons, as explained above. The rhombohedron, when its vertical axis is reduced in length to zero, becomes the single basal plane lettered $O$ in the series. If, on the contrary, the vertical axis of the rhombohedron is lengthened to infinity, the faces of the rhombohedron become
those of a six-sided prism. This last will be seen from the relations of the planes $R$ to $I$ on flg. 8, and from the approximation to a prismatic form in the planes 16 of fig. 15 . For an explanation of the lettering of other planes on rhombohedral crystals, reference must be made to the "Text-Book of Mineralogy."
3. Hemihedrism. Tetartohedrism. - Hemihedrism occurs among rhombohedral forms, similar to that in fig. 13, page 48, except that the suppressed planes of one pyramid are alternate with those of the other. One of these is represented in fig. 24. The planes $6-\frac{6}{8}$ are six in number at each extremity, and are so situated that they give a spiral aspect to the crystal. If these planes were only three in number at each extremity, the alternate three of the six, the form would be tetartohedral to the double six-sided pyramid; that is, there would be one-fourth the number of planes that exist in the double twelvesided pyramid, or 6 planes instead of 24 . Such cases of hemihedrism and tetartohedrism are common in crystals of quartz, and when existing, the crystals are said to be plugihedral, from the Greek for oblique and
 face. In some crystals the spiral turns to the right and in others to the left, and the two kinds are distinguished as right-handed and left-handed. There are also tetartohedral forms in which one whole pyramid of a scalenohedron, or of a rhombohedron, is wanting. For example, in crystals of tourmaline rhombohedral planes, and sometimes scalenohedral, may occur at one extremity of the prism and be absent from the other. This dissimilarity in the two extremities of a crystal of tourmaline is connected with pyro-electric polarity in the mineral. Three-sided prisms, hemihedral to the hexagonal prism, are common in some rhombohedral species, as tourmaline.
4. Cleavage.-Cleavage usually takes place parallel to the faces of a rbombohedron, as in calcite, corundum. Not unfre-
 quently the rhombohedral cleavage is wanting, and there is highly perfect cleavage parallel to the basal plane, as in graphite, brucite.
5. Irregularities of Crystals.-Distartions occur of the same nature with those under the other systems. Some examples are given under quartz. Some rhombohedral species, as dolomite, have the opposite faces convex or concave, as in fig. 25.

Occasional curved crystals occur, as in fig. 26, representing crystals of quartz, and fig. 2 of a crystal of chlorite. The


QUARTZ.


CILORITE.
feathery crystallizations on windows, called frost, are examples of curved forms under this system.

## VII. DISTINGUISHING CHARACTERS OF THE SEVERAL

 SYSTEMS OF CRYSTALLIZATION.1. Isometric System.- (1) There may be symmetrical groups of 4 and 8 similar planes about the extremities of each cubic axis; and of 3 or 6 similar planes about the extremities of each octahedral axis. (2) Simple holohedral forms may consist of 6 (cube), 8 (octahedron), 12 (dodecahedron), 24 (trapezohedron, trigonal trisoctahedron, and tetrahexahedron), and 48 (hexoctahedron) planes.
2. Dimetric Sxstem.-(1) Symmetrical groups of 4 and 8 similar planes occur about the extremities of the vertical axis only. (2) Prisms occur parallel only to the vertical axis; and these prisms are either square or eight-sided. (3) The simple hololredral forms may consist of 2 planes (the bases), of 4 planes (square prisms), of 8 planes (eight-sided prisms and square octahedrons), of 16 planes (double eight-sided pyramids).
3. Trimetric System.-(1) Symmetrical groups of 4 similar planes may occur about the extremities of either axis, but those of one axis belong equally to the others. (2) The prisms are rhombic prisms only, and these may occur parallel to either axis, the horizontal as well, as the vertical. (3) Simple holo-
hedral forms may consist of 2 planes (the bases, and each pair of diametral planes), of 4 planes (rhombic prisms in the three axial directions), and of 8 planes (the rhombic octahedrons). (4) The forms may be divided into equal halves, symmetrical in planes, along each of the diametral sections.
4. Monoclinic System. - (1) No symmetrical groups of similar planes ever occur around the extremities of either axis. (2) The prisms are rhombic prisms, and these can occur parallel only to the vertical axis and the clinodiagonal. (3) The planes occurring in vertical sections above and below the basal section, either in front or behind, are all unlike in inclination to that section, excepting the prismatic planes in the orthodiagonal zone; in other words, true prisms occur in no vertical section excepting the orthodiagonal. (4) Simple forms consist of 2 planes (the bases, the diametral planes, and hemiorthodomes), of 4 planes (rhombic prisms in two directions and hemioctahedrons). (4) The forms may be divided into equal and similar halves only along the clinodiagonal section. No interfacial angle of $90^{\circ}$ occurs except between the planes of the clinodiagonal zone and the clinopinacoid.
5. Triclinic System. - In triclinic crystals there are no groups of similar planes which include more than 2 planes, and hence the simple forms consist of 2 planes only. The forms are not divisible into halves having symmetrical planes. There are no interfacial angles of $90^{\circ}$.
6. Hexagonal System.-Symmetrical groups of 3, 6, and 12 similar planes may occur about the extremities of the vertical axis. (2) Prisms occur parallel to the vertical axis, and are either six or twelve-sided (3 in a hemihedral form) and equilateral. (3) Simple holohedral forms may consist of 2 planes (the basal), of 6 planes (hexagonal prism), of 12 planes (twelvesided prisms and double six-sided pyramids), of 24 planes (double twelve-sided pyramids). Simple rhombohedral forms may consist of 2 planes (the basal), of 6 planes (rhombohedrons), and of 12 planes (scalenohedrons).

## 2. TWIN, of COMPOUND CRYSTALS.

Compound crystals consist of two or more single crystals, united usually parallel to an axial or diagonal section. A few are represented in the following figures. Fig. 1 represents a crystal of snow of not unfrequent occurrence. As is evident
to the eye, it consists either of six crystals meeting in a point, or of three crystals crossing one another ; and besides, there are numerous minute crystals regularly arranged along the rays. Fig. 2 represents a cross (cruciform) crystal of staurolite, which

is similarly compound, but made up of two intersecting crystals. Fig. 3 is a compound crystal of gypsum, and fig. 4 one of spinel. These will be understood from the following figures.


Fig. 5 is a simple crystal of gypsum ; if it be bisected along $a b$, and the right half be inverted and applied to the other, it will form fig. 3, which is therefore a twin crystal in which one half has a reverse position from the other. Fig. 6 is a simple octahedron; if it be bisected along the plane $a b c d e$, and the upper half, after being revolved half way around, be then united to the lower, it will have the form in fig. 4. Both of these, therefore, are similar twins, in which one of the two comvonent parts is reversed in position.

Crystals like figs. 3 and 4 have proceeded from a compound nucleus in which one of the two molecules was reversed; and those like fig. 1 , from a nucleus of three (or six) molecules. Compound crystals of the kinds above described, thus differ from simple crystals in having been formed from a nucleus of two or more united molecules, instead of from a simple nucleus.

Compound crystals are generally distinguished by their re-entering angles, and often also by the meeting of striæ at an angle along a line on a surface of a crystal, the line indicating the plane of junction of the two crystals.

Compound crystals are called twolings, threelings, fourlings, according as they consist of two, three, or four united crystals.

Fig. 1 represents a threeling, and 2, 3, and 4, twolings. In 3 and 4 the combined crystals are simply in contact along the plane of junction; in 2 they cross one another; the former are called contact-twins and the latter penetration-twins.

Besides the above, there are also geniculated crystals, as in the annexed figure of a crystal of rutile. The bending has here taken place at equal distances from the centre of the crystal, and it must, therefore have been subsequent in time to the commencement of the crystal. The prism began from a simple molecule; but after attaining a certain length an abrupt change of direction took place. The angle of geniculation is constant in the same

## 7.

 mineral species, for the same reason that the interfacial angles of planes are fixed; and it is such that a cross section directly through the geniculation is parallel to the position of a common secondary plane. In the figure given the plane of geniculation is parallel to one of the terminal edges. In rutile the geniculated crystals sometimes repeat the bendings at each end until the extremities meet to form a wheel-like twin.

In some species, as albite, the reversion of position on which this kind of twin depends, takes place at so short intervals that the crystal consists of parallel plates, 8. 9. each plate often less than a twentieth of an inch in thickness. A section of such a crystal, made transverse to the plate, is given in fig. 8 ; without the twinning the section would have been as in fig. 9. The plates, as the figure shows, make with one another at their edges a re-entering angle (in albite an angle of $172^{\circ}$ $48^{\prime}$ ), and hence a plane of the albite crystal at right angles to the twinning direction, is covered with a series of ridges and depressions which are so minute as to be only fine striations, sometimes requiring a magnifying power to distinguish. Such striations in albite are therefore an indication of the compound structure.

This kind of twinning is owing to successive changes of polarity in the molecules as the enlargement of the crystal went forward. It occurs in all the triclinic feldspars, and is a means of distinguishing them from orthoclase.

In some twin crystals the two component parts of the crystal are not united by an even plane, but run.
 into one another with great irregularity. Cases of this kind occur in the species of quartz in twins made up of the forms $R$ and $-R$ (or -1 ). In fig. 10 the shaded parts of the pyramidal planes are of the form -1, and the non-shaded parts of R. Each of the faces is made up partly of $R$ and partly of -1 . The limits of the two are easily seen on holding the crystal up to the light, since the -1 portion is less well polished than the other. In this crystal, as in other crys. tals of quartz, the striations of planes $i$ are owing to oscillations between pyramidal and prismatic planes while the formation of the latter was in progress.

## 3. CRISTALLINE AGGREGATES.

The crystalline aggregates here included are the simple, not the mixed ; that is, they are those consisting of crystalline individuals of a single species.

The crystalline individuals may be (1) distinct crystals ; (2) fibres or columns; (3) scales or lamellæ; or (4) grains, either cleavable or not so.

1. Consisting of distinct crystals.-The distinct crystal may be either long or short prismatic, stout or slender to acicular. (needle-like), and capillary (hair-like); or they may have any other forms of crystals. They may be aggregated (a) in lines; (b) promiscuously with open spaces; (c) over broad surfaces; (d) about centres. The various kinds of aggregates thus made are:
a. Filiform.-Thread-like lines of crystals, the crystals often not well defined.
b. Dendritic.-Arborescent slender spreading branches, somewhat plant-like, made up of more or less distinct crystals, as in the frost on windows, and in arborescent forms of native copper, silver, gold, etc.

Fig. 11 represents, much magnified, an arborescent form of magnetite occurring in mica at Pennsbury, in Pennsylvania. Arborescent delineations over surfaces of rock are usually called
dendrites. They have been formed by crystallization from a solution of mineral matter which has entered by some crack and spread between the layers of the rock. They are often black, and consist of oxide of manganese ; others, of a brownish color, are made of limonite; others, of a reddish black or black color, of hematite. Moss-like forms also occur, as in moss agate.
c. Reticulated. - Slender prismatic crystals promiscuously crossing, with open spacings.
d. Divergent.-Free crystals radiating from a central
 point.
e. Drusy.-A surface is drusy when made up of the extremities of small crystals.
2. Consisting of columnar individuals.
a. Columnar, when the columnar individuals are stout.
b. Fibrous, when they are slender.
c. Parallel fibres, when the fibres are parallel.
d. Radiated, when the columns or fibres radiate from centres.
e. Stellated, when the radiations from a centre are equal around, so as to make star-like or circularly-radiated groups.
$f$. Globular, when the radiated individuals make globular or hemispherical forms, as in wavellite.
g. Botryoidal, when the globular forms are in groups, a little like a bunch of grapes. The word is from the Greek for a bunch of grapes.
h. Mammillary, having a surface made up of low and broad prominences. The term is from the Latin mammilla, a little tcat.
i. Coralloidal, when in open-spaced groupings of slender stems, looking like a delicate coral. A result of successive additions at the extremity of a prominence, lengthening it into cylinders, the stems generally having a faintly radiated structure.

Specimens of all these varieties of columnar structure, excepting the last, often have a drusy surface, the fibres or ending in projecting crystals.
3. Consisting of scales or lamello.
a. Plumose, having a divergent arrangement of scales, as seen on a surface of fracture; e. g., plumose mica.
b. Lamellar, tabular, consisting of flat lamellar crystalline individuals, superimposed and adhering.
c. Micaceous, having a thin fissile character, due to the aggregation of scales of a mineral which, like mica, has eminent cleavage.
d. Septate, consisting of openly-spaced intersecting tabular individuals; also divided into polygonal portions by reticulating veins or plates. A septarium is a concretion, usually flattened spheroidal in shape, the solid interior of which is intersected by partitions; these partitions are the fillings of cracks in the interior that were due to contraction on drying. When the surface of such septate concretions has been worn off, they often have the appearance of a turtle's back, and are sometimes taken for petrified turtles.
4. Consisting of grains. Granular structure. A massive mineral may be coarsely granular or finely granular, as in varieties of marble, granular quartz, etc. It is termed saccharoidal when cvenly granular, like loaf sugar. It may also be cryptocrystalline, that is, having no distinct grains that can be detected by the unaided eye, as in flint. The term cryptocrystalline is from the Greek for concealed crystalline. Aphanitic, from the Greek for invisible, has the same signification. The term ceroid is applied when this texture is connected with a waxy lustre, as in some common opal.

Under this section occur also globular, botryoidal, and mammillary forms, as a result of concretionary action in which no distinct columnar interior structure is produced. They are called pisolitic when in masses consisting of grains as large as peas (from the Latin pisum, a pea), and oölitic when the grains are not larger than the roe of a fish, from the Greek for egg.
5. Forms depending on mode of deposition.-Besides the above, there are the following varieties which have come from mode of deposition :
a. Stalactitic, having the form of a cylinder, or cone, hanging from the roofs of cavities or caves. The term stalactite is usually restricted to the cylinders of carbonate of calcium hanging from the roofs of caverns; but other minerals are said to have a stalactitic form when resembling these in their general shape and origin. Chalcedony and brown iron ore are often stalactitic. Interiorly the structure may be either granular, radiately fibrous, or concentric.
b. Concentric.-When consisting of lamellæ, lapping one over another around a centre, a result of successive concretionary aggregations, as in many concretionary forms, most pisolite, part of oülite, some stalactites, etc..
c. Stratified, consisting of layers, as a result of deposition : c. g., some travertine, or tufa.
d. Banded ; color-stratified. Like stratified in origin, but the layers usually indicated only by variations in color ; the banding is shown in a transverse section : e. $g$., agate, much stalagmite, riband jasper.
e. Geodes.-When a cavity has been lined by the deposition of mineral matter, but not wholly filled, the enclosing mineral is called a geode. The mineral is often banded, owing to the successive depositions of the material, and frequently has its inner surface set with crystals. Agates are often slices or fragments of geodes.
6. Forms derived from the crystals of other minerals. Pseu-domorphs.-Crystalline aggregates, especially the granular, sometimes have forms derived from the crystals of other minerals either
(1) Because a result of cotemporaneous removal and substitution ; or
(2) Because a result of the alteration of such crystals; or
(3) Because filling spaces that had been left occupied in consequence of previous removal.

For example. Crystals occur having the forms of calcite (calcium carbonate, or " carbnnate of lime"), but consisting of quartz or silica. They were made from calcite crystals by the action of some solution containing silica, the solution dissolving away the calcite and depositing at the same time silica or quartz. Specimens occur showing all stages in the change from the earliest in which the calcite is thinly coated with quartz, to tho last, in which it is all quartz. Such crystals are pseudomorphs of quartz after calcite. Siliceous fossil shells and corals are similar 1 seudomorphs after calcite, since shells and corals consist chiefly of calcite. Other quartz pseudomorphs have the form of flaorite, barite, etc.

Again, the forms of calcite occur with the constitution of limonite, a hydrous iron oxide. In such a case the iron oxide was in the solution that corroded and dissolved away the calcite.

Again, the forms of calcite occur with the constitution of serpentine, a hydrous magnesium silicate; and in this case the ingredients of the serpentine silicate were present when the
calcite was dissolved away by the corrosive solvent, and took its place as the calcite particles were removed.

In all the above cases the pseudomorphs were made by simple removal and cotemporaneous substitution.

Again, crystals of the form of chrysolite, a magnesium silicate, occur, altered to serpentine, a hydrous magnesium silicate. Here the pseudomorph was made by a process of alteration, part of the ingredients remaining, and only water added.

Again, crystals of siderite (spathic iron or iron carbonate) occur changed to limonite, a hydrous iron oxide. Here there was an oxidation of the iron of the carbonate, and the addition of water. This is another example of $p$ seudomorphs by alteration. Similarly orthoclase changes to kaolin, and kaolin has the form at times of orthoclase crystals.

Again, crystals of the form of those of common salt occur consisting of clay or of calcite, which were made by deposition in a cavity left by the dissolving away of an imbedded crystal of salt. These are pseudomorphs by deposition.

Again, crystals of aragonite, prismatic calcium carbonate, occur consisting of calcite or rhombohedral calcium carbonate; and here there is a change in crystallization without any change of chemical composition.
7. Fracture.-Kinds of fracture in these crystalline aggregates depend on the size and form of the particles, their cohesion, and to some extent their having cleavage or not.

Among granular varieties, the influence of cleavage is in all cases very small, and in the finest almost or quite nothing. The term hackly is used for the surface of fracture of a metal, when the grains are coarse, hard, and cleavable, so as to be sharp und jagged to the touch; even, for any surface of fracture when it is nearly or quite flat, or not at all conchoidal; conchoidal, when the mineral, owing to its extremely tine or cryptocrystalline texture and hardness, breaks with shallow concavities and convexities over the surface, as in the case of flint. The word conchoidal is from the Latin concha, a shell. These kinds of fracture are not of much importance in mineralogy, since they distinguish varieties of minerals only, and not species.

## 2. PHYSICAI PROPERTIES OF MINERALS.

The physical properties referred to in the description and determination of minerals are here treated under the following heads: (1) Hardness; (2) Tenacity; (3) Specific Gravity; (4) Refraction, Polarization; (5) Diaphaneity, Color, Lustre; (6) Electricity and Maguetism ; (7) 'Taste and Odor.

## 1. HARDNESS.

The comparative hardness of minerals is easily ascertained, and should be the first character attended to by the student in examining a specimen. It is only necessary to draw a file across the specimen, or to make trials of scratching one with another. As standards of comparison the following minerals have been selected, increasing gradually in hardness from talc, which is very soft and easily cut with a knife, to the diamond. This table, called the scale of harduess, is as follows:

1 , talc, common foliated variety; 2, rock salt ; 3, calcite, transparent variety ; 4, fluorite, crystallized variety; 5., apatite, transparent crystal ; 6, orthoclase, cleavable variety ; 7, quartz, transparent variety ; 8, topaz, transparent crystal ; 9, sapphire, cleavable variety; 10, diamond.

If, on drawing a file across a mineral, it is impressed as easily as fluorite, the hardness is said to be 4; if as easily as orthoclase, the hardness is said to be 6 ; if more easily than orthoclase, but with more difficulty than apatite, its hardness is described as $5 \frac{1}{2}$ or $5 \cdot 5$.

The file should be run across the mineral three or four times, and care should be taken to make the trial on angles equally blunt, and on parts of the specimen not altered by exposure. Trials should also be made by scratching the specimen under examination with the minerals in the above scale, since sometimes, owing to a loose aggregation of particles, the file wears down the specimen rapidly, although the particles are very hard.

In crystals the hardness is sometimes appreciably different in degree in the direction of different axes. In crystals of
the hardness is less on the basal plane of the prism, that is, on the cleavage surface, than it is on the sides of the prism. On the contrary, the termination of a crystal of cyanite is harder than the lateral planes. The degree of hardness in different directions may be obtained with great accuracy by means of an instrument called a sclerometer.

## 2. TENACITY.

The following rather indefinite terms are used with reference to the qualities of tenacity, malleability, and flexibility in minerals:

1. Brittle.-When a mineral breaks easily, or when parts of the mineral separate in powder on attempting to cut it.
2. Malleable.-When slices may be cut off, and these slices will flatten out under the hammer, as in native gold, silver, copper.
3. Sectile.-When thin slices may be cut off with a knife. All malleable minerals are sectile. Argentite and cerargyrite are examples of sectile ores of silver. The former cuts nearly like lead and the latter nearly like wax, which it resembles. Minerals are imperfectly sectile when the pieces cut off pulverize easily under a hammer, or barely hold together, as selenite.
4. Flexible. - When the mineral will bend, and remain bent after the bending force is removed. Example, talc.
5. Elastic. When, after being bent, it will spring back to its original position. Example, mica.

A liquid is said to be viscous when on pouring it the drops lengthen and appear ropy. Example, petroleum.

## 3. SPECIFIC GRATITY.

The specific gravity of a mineral is its weight compared with that of some substance taken as a standard. For solids and liquids distilled water, at $60^{\circ} \mathrm{F}$., is the standard ordinarily used ; and if a mineral weighs twice as much as water, its specific gravity is 2 ; if three times it is three. It is then necessary to compare the weight of the mineral with the weight of an equal bulk of water. The process is as follows:

First weigh a fragment of the mineral in the ordinary way,
with a delicate balance; next suspend the mineral by a hair, or fibre of silk, or a fine platinum wire, to one of the scales, immerse it thus suspended in a glass of distilled water (keeping the scales clear of the water) and weigh it again; subtract the second weight from the first, to ascertain the loss by immersion, and divide the first by the difference obtained; the result is the specific gravity. The loss by immersion is equal to the weight of an equal volume of water. The trial should be made on a small fragment; two to five grains are best. The specimen should be free from impurities and from pores or air-bubbles. For exact results the temperature of the water should be noted, nnd an allowance be made for any variation from the height of thirty inches in the barometer. The observation is usually made with the water at a temperature of $60^{\circ} \mathrm{F} . ; 39^{\circ} \cdot 5 \mathrm{~F}$., the temperature of the maximum density of water, is preferable.

The accompanying figure represents the spiral balance of Jolly, by which the weight is measured by the torsion of a spiral brass wire. On the side of the upright ( $A$ ) which faces the spiral wire, there is a graduated mirror, and the readings which give the weight of the mineral in and out of water are made by means of an index (at $m$ ) connected with the spiral wire; and its exact height, with reference to the graduation, is obtained by noting the coincidence between it and its image as reflected by the graduated mirror. $c$ and $d$ are the pans in which the piece of mineral is placed, first in $c$, the one out of the water, and then in $d$, that in the water.

Another process, and one available for porous as well as compact minerals, is performed with a light glass bottle, capable of holding exactly a thousand grains (or any known weight) of distilled water. The specimen should be reduced to a coarse powder. Pour out a few drops of water from
 the bottle and weigh it; then add the powdered mineral till the water is again to the brim, and reweigh it; the difference in the two weights, divided by the loss of water poured out, is the specific gravity sought. The weight of the glass bottle itself is here supposed to be balanced by an equivalent weight in the other scalc.

## 4. REFRACTION AND POLARIZATION.

Minerals differ widely in their refracting and polarizing properties, and hence these properties are a convenient means of distinguishing species. The explanations of the subject, and the methods of careful experimenting, will be found in treatises on optics, and also at considerable length, and with minute directions as to the use of instruments, in the Text-Book of Mineralogy. Only a few of the simpler facts required for the ordinary purposes of the mineralogist are here mentioned.

The character of the refraction varies according to the system of crystallization.
A. In isometric crystals there is simple refraction alike in all directions, and no polarization.
B. In dimetric and hexagonal crystals the vertical axis, or axis of symmetry, is the direction of the optic axis; in all directions except this a transmitted ray of light is doubly refracted. Such crystals are optically uniaxial.
C. In trimetric, monoclinic, and triclinic crystals, which have the three axes unequal, there are tuco directions of no double-refraction. Such crystals are optically biaxial.

1. Isometric System.-In the isometric system there is no reference whatever in the refraction to crystalline structure, and in this respect substances thus crystallizing are like water. There is only simple refraction. The index of refraction is obtained by dividing the sine of the angle of incidence of a ray of light by the sine of its angle of refraction. Thus if a ray of light strike the surface of a transparent plate of the mineral at an angle of $40^{\circ}$ from the perpendicular, and then passes through the plate at an angle of $30^{\circ}$ from the perpendicular, owing to the refraction, the sine of $40^{\circ}$ divided by the sine of $30^{\circ}$ will be the index of refraction. Now the index of refraction of air being made the unit, that of water is 1.335 ; of fluorite, 1.434 ; of rock salt, 1.557 ; of spinel, 1.764 ; of garnet, 1.815 ; of blende, $2 \cdot 260$; of diamond, $2 \cdot 439$.
2. Crystals Unicacicl in Polarization.-A transparent cleavage plate from a crystal of calcite shows what is called double refraction. Placed over a line drawn on any surface, two parallel lines are seen, one produced by the ordinary ray, and the other by the extraordinury ray. Both rays are polarized, and in planes at right angles to each other. Prisms, called Nicol prisms, made from transparent calcite (Iceland Spar), are employed for obtaining polarized light. Transparent
plates of tourmaline, cut from a crystal parallel to the vertical axis, also are used for this purpose. Another method of obtaining it is by reflection-light, when reflected at a certain angle from a polished surface, being polarized; the angle of reflection differs for different substances.
3. 



The above figure represents a simple polariscope made with two tourmaline plates, which is convenient for many ordinary observations. The best instruments for the purpose are made with Nicol prisms, and are adapted to microscopic work. The prisms, placed within the tube of the instrument, one of them below the stage, are arranged so as to admit of revolution; and the stage also has a graduated circle and revolves. The compound microscope also is uften converted into a polariscope by Nicol prisms arranged for this purpose.

When a crystal with one axis of polarization, as, for example, calcite, is cxamined by means of a ray of polarized light passed in the direction of the vertical axis, concentric circular rings are seen, having the colors of the spectrum intersected by either a black or a white cross, as in figs. 1, 2. To make the observa-

tion it is necessary that the calcite crystal should have its extremities polished at right angles to the vertical axis. If a tourmaline plate be placed against or near one of its polished
faces, and a similar tourmaline plate in front of the opposite face, the colored rings will be seen on looking through; and by revolving one of the tourmaline plates a change will be observed at each $90^{\circ}$ of revolution, in the colors of the rings, and in the variations in appearance of the cross from black to white, and the reverse. The fact in any case that the rings of color are perfect circles, and the black cross a symmetrical one, is proof that the crystal is either of the dimetric or hexagonal system. But sometimes very exact observation is necessary to determine the truth.
3. Crystals Biaxial in Polarization.-Biaxial crystals aro those having two optic axes, and the angle between them is called the axial angle.

When a section of such a crystal, at right angles to the line bisecting the acute axial angle, is viewed in converging polarized light, the two axes are seen with a series of elliptical colored rings surrounding each. If the section is so placed that the line joining the axes coincides with the vibration-plane of either Nicol prism, or tourmaline plate, an unsymmetrical


## 6.



PHLOGOPITE, ANTWERP, N. Y.
black cross is also seen, as in fig. 4 ; if it makes an angle of $45^{\circ}$ with this, two curved black bars are observed, as in fig. 5. In either case the colors are reversed, and the black changed to white as one of the Nicols is revolved. Fig. 6 shows the axial figure for phlogopite (in the second position mentioned above) where the axial angle is very small. The rings are less numerous and farther apart the thinner the section that is employed in making the observations.

In muscovite (common mica) the angle between the axes is $50^{\circ}$ to $70^{\circ}$, and, if the tourmaline tongs are employed, the two
series of rings are visible only when viewed in directions very oblique to one another.
4. Circular Polarization in Uniaxial Crystals.-It is stated on page 53 that quartz crystals have often a left-handed and a right-handed arrangement of planes. This is connected with a right-handed and left-handed molecular structure in crystals of this species. When a plate cutat right angles to the axis is examined by the polarized light, instead of presenting a black cross, the centre of the rings appears brightiy colored, and if the polarizer is revolved, this color changes from blue to yellow, then red, right-handed crystals requiring revolution to the right and left-handed to the left for this succession. This property seems to distinguish the smallest grains of quartz, and may be easily observed in a good polariscope.
5. Anomalies in Polarization.-There are some isometric crystals which have the property of polarization. Boracite is one example; and it is explained by the presence of another mineral in minute particles, distributed regularly through the crystals. Perofskite is another case; and it has suggested a doubt as to its being isometric. Octahedrons of alum sometimes have polarization, and it has been shown to be due to the crystals being made up of thin plates-light, when transmitted through a pile of such plates, becoming polurized. Diamonds are sometimes uniaxial.

Analcite was long since described by Sir David Brewster as an example of polarization under the isometric system. Its trapezohedrons exhibit a symmetrical arrangement of lines of prismatic colors and alternating dark
 lines with cross-bands, as imperfectly shown in the annexed figure. Trapezohedrons of leucite are somewhat similar in their polarizing character. The effect in both speecies is connected with twinning; but, besides, according to recent observers, the crystallization is dimetric. One writer makes crystals of analcite to be trimetric twins, analogous those of phillipsite. Twinning in crystals is a very common source of irregularities. A regular twinning of laminæ of biaxial crystals around a centre may give a uniaxial character to the twin. Apophyllite is a dimetric species, showing peculiarities in its colors arising from the different action of the mineral in light of different colors.

## 5. DIAPHANEITY, LUSTRE, COLOR.

## 1. Diaphaneity.

Diaphaneity is the property which many objects possess of transmitting light; or, in other words, of permitting more or less light to pass through them. This property is often called transparency, but transparency is properly one of the degrees of diaphancity. The following terms are used to express the different degrees of this property:

Transparent-a mineral is said to be transparent when the outlines of objects, viewed through it, are distinct. Example, glass, crystals of quartz.

Subtransparent, or semitransparent-when objects are seen but their outlines are indistinct.

Translucent-when light is transmitted, but objects are not seen. Loaf sugar is a good example; also Carrara marble.

Subtranslucent - when merely the edges transmit light faintly.
When no light is transmitted the mineral is described as opaque.

## 2. Lustre.

The lustre of minerals depends on the nature of their surfaces, which causes more or less light to be reflected. There are different degrees of intensity of lustre, and also different kinds of lustre.
a. The kinds of lustre are six, and are named from some familiar object or class of objects.

1. Metallic-the usual lustre of metals. Imperiect metallic lustre is expressed by the term submetallic.
2. Vitreous-the lustre of broken glass. An imperfect vitreous lustre is termed subvitreous. Both the vitreous and subvitreous lustres are common. Quartz possesses the former in an eminent degree; calcareous spar often the latter. This kind of lustre may be exhibited by minerals of any color.
3. Resinous-lustre of the yellow resins. Example, some opal, zinc blende.
4. Pearly-like pearl. Example, talc, native magnesia, stilbite, etc. When united with submetallic lustre the term metallic-pearly is applied.
5. Silky-like silk; it is the result of a fibrous structure.

Example, fibrous calcite, fibrous gypsum, and many fibrous minerals, more especially those which in other forms have a pearly lustre.
6. Adamantine-the lustre of the diamond. When submetallic, it is termed metallic adamantine. Example, some varieties of white lead ore or cerussite.
b. The degrees of intensity are denominated as follows:

1. Splendent-when the surface reflects light with great brilliancy and gives well-defined images. Example, Elba hematite, tin ore, some specinens of quartz and pyrite.
2. Shining-when an image is produced, but not a well-defined image. Example, calcite, celestite.
3. Glistering-when there is a gencral reflection from the surface, but no image. Example, talc.
4. Glimmering-when tho reflection is very imperfect, and apparently from points scattered over the surface. Example, flint, chalcedony.

A mineral is said to be dull when there is a total absence of lustre. Example, chalk.

## 3. Color.

1. Kinds of Color.-In distinguishing minerals, both the external color and the color of a surface that has been rubbed or scratched, are observed. The latter is called the streak, and the powder abraded, the streak-pouder.

The colors are either metallic or unmetallic.
The metallic are named after some familiar metal, as copperred, bronze-yellow, brass-yellow, gold-yellow, steel-gray, leadgray, iron-gray.

The unmetallic colors used in characterizing minerals are various shades of white, gray, black, blue, green, yellow, red and brown.

There are thus snow-white, reddish-white, greenish-white, milk-white, yellowish-white.

Bluish-gray, smoke-gray, greenish-gray, pearl-gray, ash-gray.
Velvet-black, greenish-black, bluish-black, grayish-black.
Azure-blue, violet-blue, sky-blue, indigo-blue.
Emerald-green, olive-green, oil-green, grass-green, apple-green, bluckish-green, pistachio-green (yellowish).

Sulphur-yellow, straw-yellow, wax-yellow, ochre-yellow, honey-yellow, orange-yellow.

Scarlet-red, blood-red, flesh red, brick-red, hyacinth-red, rosered, cherry-red.

Hair-brown, reddish-brown, chestnut-brown, yellowish-brown, pinchbeck-brown, wood-brown.

A play of colors-this expression is used when several prismatic colors appear in rapid succession on turning the mineral. The diamond is a striking example; also precious opal.

Change of colors-when the colors change slowly on turning in different positions, as in labradorite.

Opalescence-when there is a milky or pearly reflection from the interior of a specimen, as in some opals, and in cat's eye.

Iridescence-when prismatic colors are seen within a crystal, it is the effect of fracture, and is common in quartz.

Tarnish-when the surface colors differ from the interior; it is the result of exposure. The tarnish is described as irised when it has the hues of the rainbow.
2. Dichroism, Tiichroism.-Some crystals, under each of the systems excepting the isometric, have the property of presenting different colors by transmitted light in different directions. The property is called dichroism when these colors are seen in two directions, and trichroism (or pleorhroism) if seen in three directions. The colors are always the same in the direction of equal axes and often unlike in the direction of unequal axes. As dimetric and hexagonal crystals have the lateral axes equal they can present different colors only in two directions, the vertical and lateral; while all crystals that are optically biaxial may be trichroic.

The mineral iolite is a noted example, and received the name dichroite on account of this property. Transparent colored crystals of tourmaline, topaz, epidote, mica, diaspore, and many other species exhibit it. Tourmaline crystals, when transparent or translucent transverse to the prism, are opaque in the direction of the vertical axis; and so also are thick crystals of mica. Colored varieties of hornblende are dichroic, while those of the related mineral, pyroxene, are not so.

This quality is best observed by means of polarized light. On examining a mineral with a tourmaline plate, or Nicol prism, the two colors in a dichroic mineral are successively seen as the tourmaline or Nicol is revolved; and if there is no dichroism there is no change of color. A small instrument, containing a prism of calcite, has been constructed for showing the dichroism, called the dichroscope. On looking through it at a dichroic crystal, the aperture against the crystal appears double, owing to the double refraction of the calcite, one image being made by the ordinary ray and the other by the extraordinary
ray; and the two colors are seen side by side, at intervals of $90^{\circ}$ in the revolution of the mineral.

For opaque minerals it is necessary to make a thin transparent section of the mineral and examine it with a polariscope, or with a microscope arranged to act as one by the addition of one Nicol prism. The opaque hornblende of rocks is thus distinguished from pyroxene, and so in other cases.
3. Asterism.-Some crystals, especially the hexagonal, when viewed in the direction of the vertical axis, present peculiar reflections in six radial directions. This arises either from peculiarities of texture along the axial portions, or from some impurities. A remarkable example of it is that of the asteriated sapphire, and the quality adds much to its value as a gem. The six rays are sometimes alternately shorter, indicating the rhombohedral character of the crystal.
4. Phosphovescence.-Several minerals give out light either by friction or when gently heated. This property of emitting light is called phosphorescence.

Two pieces of white sugar struck against one another give a feeble light, which may be seen in a dark place. The same effect is obtained on striking together fragments of quartz, and even the passing of a feather rapidly over some specimeus of zinc blende is sufficient to elicit light.

Fluorite is the most convenient mineral for showing phosphorescence by heat. On powdering it, and throwing it on a plate of metal beated nearly to redness, the whole takes on a bright glow. In some varieties the light is emerald green; in others, purple, rose, or orange. A massive fluor, from Huntington, Connecticut, shows beautifully the emerald green phosphorescence.

Some kinds of white marble, treated in the same way, give out a bright yellow light.

After being heated for a while the mineral loses its phosphorescence; but a fow electric shocks will, in many cases, to some degree restore it again.

## 6. ELECTRICITY, AND MAGNETISM.

-Many minerals become electrified on being rubbed, so that they will attract cotton and other light substances; and when electrified some exhibit positive and others negative electricity, when brought near a delicately suspended magnetic needle. The diamond, whether polished or not, ai-

## 3. CHEMICAL PROPERTIES OF MINERALS.

The chemical properties of minerals are of two kinds. (1) Those of the chemical composition of minerals, (2) those depending on their chemical reactions, with or without fluxes, including results obtained by means of the blowpipe.

## 1. Chemical Composition.

All the elements mado known by chemistry are found in minerals, for the inineral kingdom is the source of whatever living beings-plants and animals-contain or use. A list of these elements, as at present made out, is contained in the following table, together with the symbol for each used in stating the composition of substances. These symbols are abbreviations of the Latin names for the elements. A few of these Latin names differ much from the English, as follows:

| Stibium | $\mathrm{Sb}=$ Antimony | Kalium | $\mathrm{F}=$ Potassium |
| :--- | :--- | :--- | :--- |
| Cuprum | $\mathrm{Cu}=$ Copper | Argentum | $\mathrm{Ag}=$ Silver |
| Ferrum | $\mathrm{Fe}=$ Iron | Natrium | $\mathrm{Na}=$ Sodium |
| Plumbum | $\mathrm{Pb}=$ Lead | Stannum | $\mathrm{Sn}=$ Tin |
| Hydrargyram | $\mathrm{Hg}=$ Mercury | Wolframium | $\mathrm{W}=$ Tungsten |

Table of tie Elements.

| Aluminum | Al | $27 \cdot 4$ | Columbium (Niobium) | $\mathrm{Cb}(\mathrm{Nb})$ | ) 94 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Antimony | Sb | 120 | Copper | Ca | 63.4 |
| Arsenic | As | 75 | Didymium | D | $144 \cdot 8$ |
| Barium | Ba | 137 | Erbium | E | 168.9 |
| Bismuth | Bi | 210 | Fluorine | F | 19 |
| Boron | B | 11 | Gallium | Ga | 68 ? |
| Bromine | Br | 80 | Glucinum (Beryllium) | G ( Be ) | ) 94 |
| Cadmiam | Cd | 112 | Gold | Au | 197 |
| Cassium | Cs | 133 | Hydrogen | H | 1 |
| Calcium | Ca | 40 | Indium | In | 113.4 |
| Carbon | C | 12 | Iodine | I | 127 |
| Ceriun | Ce | 138 | Iridium | Ir | 198 |
| Chlorine | (1) |  | Iron | Fe | 56 |
| Chromium | Cr |  | Lanthanum | La | 139 |
| Cobalt | Co | 58.8 | Lead | Pb 2 | 207 |


| Lithium | Li | 7 | Silver | Ag | 108 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Magnesium | Mg | 24 | Silicon | Si | 28 |
| Manganese | Mn | 55 | Sodium | Na | 23 |
| Mercury | Hg | 200 | Strontium | Sr | 87.0 |
| Molybdenum | Mo | 96 | Sulphur | S | 32 |
| Nickel | Ni | 58.8 | Tantalum | Ta | 182 |
| Nitrogen | N | 14 | Tellurium | Te | 128 |
| Osmium | Os | 189.2 | Thallium | Tl | 204 |
| Oxygen | 0 | 16 | Thorium | Th | 235 |
| Palladium | Pd | 106.6 | Tin | Sn | 118 |
| Phosphorus | P | 31 | Titanium | Ti | 50 |
| Platinum | Pt | 187.6 | Tungsten | W | 184 |
| Potassium | K | $39 \cdot 1$ | Uranium | U | 240 |
| Rhodium | Ro | $104 \cdot 4$ | Vanadium | V | 51.2 |
| Rubidium | Rb | $85 \cdot 4$ | Yttriam | Y | 92 |
| Ruthenium | Ru | 104.4 | Zinc | Zn | 65.2 |
| Selenium | Se | $79 \cdot 4$ | Zirconium | Zr | $89 \cdot 6$ |

The combining weights indicate the proportions in which the elements combine. Thus, assuming hydrogen, the lightest of the elements, to be 1, or the unit of the series, the combining weight of oxygen is 16 ; of iron, 56 ; of magnesium, 24 ; of sulphur, 32 ; and so on. When hydrogen and oxygen combine it is in the ratio of 2 pounds of hydrogen, or else 1 pound of hydrogen, to 16 pounds of oxygen, and two different compounds thus result. When oxygen and magnesium combine it is in the ratio of 16 pounds of oxygen to 24 of magnesium. Oxygen and iron combine in the ratio of 16 of oxygen to 56 of iron; or of 24 of oxygen ( $1 \frac{1}{2}$ times 16) to 56 . Sulphur and oxygen combine in the ratio of 32 of oxygen to 32 of sulphur; or of 48 to 32 of sulphur. The combining weights are often called the atomic weights.

The following is the manner of using the symbols: For the compound consisting of hydrogen and oxygen in the ratio of 2 to 16 , the chemical symbol is $\mathrm{H}_{4} \mathrm{O}$, meaning 2 of hydrogen to 1 of oxygen. (This compound is water.) For the compound of oxygen and magnesium just referred to, the symbol is MgO ; for the two compounds of oxygen and iron, FeO , protoxide of iron; $\mathrm{Fe}_{2} \mathrm{O}_{3}$, sesquioxide of iron, the ratio of 1 to $1 \frac{1}{2}$ being expressed by 2 to 3 ; for the two compounds of sulphur and oxygen, $\mathrm{SO}_{2}$ and $\mathrm{SO}_{3}$.

Some of the elements so closely resemble one another that their similar, compounds are closely alike in crystallization and other qualities, and they are therefore said to be isomorphous.

This is true of iron, magnesium, calcium, and two or three other related elements. In one group of compounds of these bases, the carbonates, the crystalline form for each is rhombohe-
dral, and among them there is a difference of less than two degrees in the angle of the rhombohedron. Besides a carbonate of calcium, a carbonate of magresium, and a carbonate of iron, there is also a carbonate of calcium and magnesium, in which half of the calcium of the first of these carbonates is replaced by half an atom of magnesium; and another species in which the base, instead of being all magnesium, is half magnesium and half iron. By half is here meaut half in the proportion of their combining weights.

The replacement of one of these elements by the other, and similar replacements among other groups of related elements, run through the whole range of mineral compounds. Thus we have sodium replacing potassium, arsenic replacing phosphorus and antinony, and so on.

In the combinations of oxygen and iron, as illustrated above, oxygen is combined with the iron in different proportions. Fe O contains 1 of Fe (iron) to 1 of O (oxygen) aud $\mathrm{Fe}_{2} \mathrm{O}_{3}$, or, as it is often written, $\mathrm{FeO}_{3}$, contains $\frac{2}{3} \mathrm{Fe}$ to 1 of O . As the iron in each of these cases satisfies the oxygen, it is evident that the iron must be in two different states, (1) a protoxicle state, and (2) a sesquioxide state. One part of iron in this sesquioxide state ( $=\frac{2}{3} \mathrm{Fe}$ ) often replaces in compounds one part of iron in the protoxide state (or 1 Fe ), with no greater change of qualities than happens in the replacement of iron by magnesium, or calcium, explained above ; or, a voiding fractions, 3 parts of Fe in the protoxide state replaces 2 Fe in the sesquioxide state. Writing Ee for the last 2 Fe , the statement becumes 1 of $\mathrm{Fe}_{3}$ replaces 1 of Fe . Aluminium occurs only in the sesquioxide state, and the ordinary symbol of the oxide is $\mathrm{Al}_{5} \mathrm{O}_{\text {. }}$, or $\mathrm{AlO}_{3}$. But it is closely related to iron in the sesquioxide state, so that, using the same mode of expression as for iron, 1 of Al replaces 1 of $\mathrm{Fe}_{3}$, or 1 of $\mathrm{Mg}_{3}$, and so on. Similarly, writing $R$ for any metal, 1 of R replaces 1 of $\mathrm{R}_{3}$. Again, in potash $\left(\mathrm{K}_{8} \mathrm{O}\right)$, soda $\left(\mathrm{Na}_{2} \mathrm{O}\right)$, lithia $\left(\mathrm{Li}_{2} \mathrm{O}\right)$, water $\left(\mathrm{H}_{2} \mathrm{O}\right)$, one of oxygen $(\mathrm{O})$ is combined soverally with 2 of K (potassium), of Na (sodium), of Li (lithium), of hydrogen; and hence 2 K , $2 \mathrm{Na}, 2 \mathrm{Li}$, that is, $\mathrm{K}_{2}, \mathrm{Na}_{2}, \mathrm{Li}_{2}$, may each replace in compounds 1 Ca , or 1 Mg , etc.

The elements potassium, sodium, lithium, hydrogen, of which it takes two parts to combine with 1 of oxygen, are called monads. Other elements of the group of monads are rubidium, coesium, thallium, silver, and also fluorine, chlorine, bromine, iodine. Still other elements combining by two parts in their oxygen or sulphur compounds, etc., are nitrogen, phosphorus,
antimony, boron, columbium, tantalum, vanadium, gold. For example, for arsenic there are the compounds $\mathrm{As}_{2} \mathrm{~S}, \mathrm{As}_{2} \mathrm{~S}_{3}$, $\mathrm{As}_{2} \mathrm{O}_{2}, \mathrm{As}_{2} \mathrm{O}_{5}$, etc. Another characteristic of these elements of the hydrogen, sodium, chlorine, and arsenic groups is that the number of equivalents of the acidic element in the compounds into which they enter is, with a rare exception, odd, and of the $1,3,5$, etc., series, and on this account they are called in chemistry perissads ; while the other elements, in whose compounds their number is of the $1,2,3$, etc. (or $2,4,6$ ) series, are called artiads. An apparent exception exists under the artiads in the sesquioxides, but this does not alter the general character of the series.

The facts above cited sustain the general statement that $\mathrm{Ca}_{3}, \mathrm{Mg}_{3}, \mathrm{Mn}_{3}, \mathrm{Zn}_{3}, \mathrm{Fe}_{3}, \mathrm{Al}, \mathrm{Fe}, \mathrm{Mn}$, have equivalent combining values, and hence in minerals often replace one another; and so also $\mathrm{Ca}, \mathrm{Mg}, \mathrm{Mn}, \mathrm{Zn}, \mathrm{Fe}, \mathrm{K}_{\mathrm{v}}, \mathrm{Na}_{\mathrm{y}}, \mathrm{Li}_{2}, \mathrm{H}_{2}$, may replace one another. Similarly, also, $A s_{2}$, or $\mathrm{Sb}_{2}$ replaces S in some minerals.

With reference to the classification of minerals the elements may be conveniently divided into two groups: (1) the Acidic, and (2) the Basic. The former includes oxygen and the elements which were termed the acidifiers and acidifiable elements in the old chemistry. They are those which have been called in mineralogy the mineralizing elements, since they are the clements which are found combined with the metals to make them ores, that is, to mineralize them. The basic are the rest of the elements. The groups overlap somewhat, but this need not be dwelt upon here.

The more important of the acidic elements are the following: oxygen, fluorine, chlorine, bromine, iodine, sulphur, selenium, tellurium, boron, chromium, molybdenum, tungsten, phosphorus, arsenic, autimony, vanudium, nitrogen, tantalum, columbium, carbon, silicon.

Again, among the compounds of these elements occurring in the mineral kingdom there are two grand divisions, the binary and the ternury. The binary consist of one or more elements of each of the acidic and basic divisions, and the ternary of one or more elements of each of these two classes, along with oxygen, fluorine, or sulphur as a third. The binary include the sulphides, arsenidss, chlorides, fluorides, oxides, etc., and the ternary the sulphates, chromates, borates, arsenates, phosphates, silicates, carbonates, etc., and also the sulph-arsenites and sulphantimonites, in which a basic metal (usually lead, copper, silver) is combined with arsenic or antimony and sulphur.

The following are examples of the symbols of binary and ternary compounds:

## 1. Binary.

1. Sulphides, Selenides.- $\mathrm{Ag}_{9} \mathrm{~S}=$ silver sulphide ; $\mathrm{Ag}_{2} \mathrm{Se}=$ silver selenide; $\mathrm{PbS}=$ lead sulphide $; \mathrm{ZnS}=$ zinc sulphide; $\mathrm{FeS}_{2}=$ iron disulphide.
2. Fluorides, Chlorides, etc. $-\mathrm{CaF}_{2}=$ calcium fluoride $; \mathrm{AgCl}$ $=$ silver chloride; $\mathrm{AgBr}=$ silver bromide; $\mathrm{AgI}=$ silver iodide; $\mathrm{NaCl}=$ sodium chloride (common salt).
3. Oxides. - $\mathrm{Al}_{2} \mathrm{O}_{3}=3\left(\mathrm{Al}_{4} \mathrm{O}\right)=$ aluminium sesquioxide; $\mathrm{As}_{2} \mathrm{O}_{3}=$ arsenic trioxide; $\mathrm{As}_{3} \mathrm{O}_{5}=$ arsenic pentoxide; $\mathrm{BaO}=$ barium oxide ; $\mathrm{B}_{2} \mathrm{O}_{3}=$ horon trioxide (boracic acid) ; $\mathrm{CaO}=$ calcium oxide (lime); $\mathrm{CO}_{2}=$ carbon dioxide (carbonic acid); $\mathrm{CrO}_{3}=$ chromium trioxide (chromic acid); $\mathrm{Cu}_{2} \mathrm{O}=$ copper suboxide; $\mathrm{CuO}=$ copper oxide ; $\mathrm{BeO}=$ beryllium oxide $; \mathrm{H}_{2} \mathrm{O}=$ hydrogen oxide (water) ; $\mathrm{FeO}=$ iron oxide; $\mathrm{Fe}_{2} \mathrm{O}_{3}=$ iron sesquioxide; $\mathrm{PbO}=$ lead oxide; $\mathrm{Li}_{2} \mathrm{O}=$ lithium oxide; MgO $=$ magnesium oxide ; $\mathrm{MnO}=$ manganese oxide $; \mathrm{Mn}_{2} \mathrm{O}_{3}=$ manganese sesquioxide; $\mathrm{MnO}_{s}=$ manganese dioxide; $\mathrm{P}_{9} \mathrm{O}_{5}=$ phosphorus pentoxide; $\mathrm{K}_{2} \mathrm{O}=$ potassium oxide $; \mathrm{SiO}_{2}=$ silicon dioxide (silica); $\mathrm{Na}_{2} \mathrm{O}=$ sodium oxide; $\mathrm{SrO}=$ strontium oxide $; \mathrm{SO}_{2}=$ sulphur dioxide (sulphurous acid); $\mathrm{SO}_{3}=$ sulphur trioxide; $\mathrm{SnO}_{9}=$ tin dioxide; $\mathrm{V}_{2} \mathrm{O}_{5}=$ vanadium pentoxide (vanadic acid); $\mathrm{WO}_{3}=$ tungsten trioxide (tungstic acid); $\mathrm{ZnO}=$ zinc oxide $; \mathrm{ZrO}_{\mathbf{2}}=$ zirconium dioxide.

The composition of these compounds may be obtained from the table of combining weights, page 76. For example, with reference to the first of them (AgS), the table gives for the combining weight of silver (Ag), 108 , and for that of sulphur, 32 . The elements exist in the compound therefore in the proportion of 108 to 32 , and from it the composition of a hundred parts is easily deduced.

If the formula were $(\mathrm{Ag}, \mathrm{Pb}) \mathrm{S}$, signifying a silver-and-lead sulphide, and if the silver and lead were in the ratio of 1 to 1 , then half the combining weight of silver is taken; that is, 54 , and half the atomic weight of lead, which is 103.5 ; and the sum of these numbers, with 32 for the sulphur, expresses the ratio of the three ingredients.

For $\mathrm{Al}_{2} \mathrm{O}_{3}$ we find the combining weight of aluminium 27.4; doubling this for $\mathrm{Al}_{8}$ makes 54.8 . Again, for oxygen, we find 16 ; and three times 16 is $48 . \quad 54 \cdot 8$ to 48 is therefore the ratio
of aluminium to the oxygen in $\mathrm{Al}_{2} \mathrm{O}_{3}$, from which the percentage proportion may be obtained.

## 2. Ternary Oxygen Compounds.

Silicates.-Of these compounds there are two prominent groups. In one of those groups the general formula is $\mathrm{RO}_{3} \mathrm{Si}$, and in the other $\mathrm{R}_{2} \mathrm{O}_{4} \mathrm{Si}$. In both of these formulas R stands for any basic elements in the protoxide state, as $\mathrm{Ca}, \mathrm{Mg}, \mathrm{Fe}$, etc., cither alone or in combination. In the first of these formulas the combining values of the basic element $R$ and the acidic element or silicon, as measured by their combinations with oxygen, are in the proportion of 1 to 2 , for $R$ stands for an elernent in the protoxide state, while Si stands for silicon, which is in the dioxide state, its oxide being a dioxide; and hence the minerals so constituted are called Bisilicates. In the second of these formulas this ratio is 2 to 2 , or 1 to 1 , and hence these are called Unisilicates.

Multiplying these formulas by 3 , they become $\mathrm{R}_{5} \mathrm{O}_{4} \mathrm{Si}_{3}$, and $\left(2 R_{3}\right) O_{12} \mathrm{Si}_{3}$; and the same composition is expressed. In this form the substitution of sesquioxide bases for protoxide may be indicated: thus, $\mathrm{R}_{2} \mathrm{H}_{\mathrm{t}} \mathrm{O}_{12}, \mathrm{Si}_{3}$ signifies that half of the $2 \mathrm{R}_{3}$ is replaced by Al or Fe , or some other element in the sesquioxide state.

There are also some species in which the ratio is 1 to less than 1, and these are called Subsilicates.

The ratio here referred to (formerly known as the oxygen ratio) is called the quantivalent ratic.

The other ternary compounds require no special remarks in this place.
2. Cifemical Reactions.

1. Trials in the wet way.
2. Test for Carbonates.-Into a test tube put a little hydrochloric acid diluted with one half water, and add a small portion in powder of the mineral. If a carbonate, there will be a brisk effervescence caused by the escape of carbonic dioxide (carbonic acid), when heat is applied, if not before. With calcium carbonate no hea' or pulverization is necessary.
3. Test for Gelatinizing Silica.-Some silicates, when pow-
dered and treated with strong hydrochloric acid, are decomposed and deposit the silica in a state of a jelly. The experiment may be performed in a test tube, or small glass flask. Sometimes the evaporation of the liquid nearly to dryness is necessary in order to obtain the jelly. Some silicates do not afford the jelly unless they have been previously ignited before the blowpipe, and some gelatinizing silicates lose the power on ignition.
4. Decomposability of Minerals by Acids.-To ascertain whether a mineral is decomposable by acids or not, it is very fiuely powdered and then boiled with strong hydrochloric acid, or, in case of many metallic minerals, with nitric acid. In some cases where no jelly is formed there is a deposit of silica in fine flakes. With the sulphides and nitric acid there is often a deposit of sulphur, which usually floats upon the surface of the fluid as a dark spongy mass. Some oxides, and also some sulphates and many phosphates, are soluble entirely without effervescence. But many minerals resist decomposition. It is sometimes difficult to tell whether a mineral is decomposed with the separation of the silica or whether it is unacted upon. In such a case a portion of the clear fluid is neutralized by soda (sodium carbonate), and if anything has been dissolved it will usually be precipitated.

Test for F'luorine.-Most fluorides are decomposed by strong heated sulphuric acid, give out fluorine which will etch a gluss plate in reach of the fumes. The trial may be made in a lead cup and the glass put over it as a loose cover.

## 2. Trials with the IBlowpipe.

The blowpipe, in its simplest form, is merely a bent tube of small size, eight to ten inches long, terminating at one end in a minute orifice. It is used to concentrate the flame on a mineral, and this is done by blowing through it while the smaller end is just within the flame.

The annexed figure represents the form commonly employed, except that the tube is usually without the division at $b$. It contains an air chamber (o) to receive the moisture which is condensed in the tube during the blowing; the moisture, unless thus removed, is often blown through the small aperture and interferes with the experiment. The jet, ef, is movable, and it is desirable that it should be made of platinum, in order that it may be cleaned when necessary, either by high heating or
by immersion in an acid. The screw at $b$ is for the purpose of shortening the tube one-half so as to make it more convenient for the pocket of the field mineralogist. It is unscrewed for this purpose, and the smaller part put within the larger.

In using the blowpipe it is necessary to breathe and blow at the same time, that the operator may not interrupt the flame in order to take breath. Though seemingly absurd, the necessary tact may easily be acquired. Let the student first breathe a few times through his nostrils while his cheeks are inflated and his mouth closed. After this practice let him put the blowpipe to his mouth and he will find no difficulty in breathing as before while the muscles of the inflated cheeks are throwing the air they contain through the blowpipe. When the air is nearly exhausted the mouth may again be filled through the nose without interrupting tho process of blowing.

The flame of a candle, or a lamp with a large
 wick may be used, and when so it should be bent in the direction the flame is to be blown. But it is far better, when gas can be had, to use a Bunsen's burner.

The Hamo has the form of a cone, yellow without and blue within. The heat is most intense just beyond the extremity of the blue flame. In somo trials it is necessary that the air should not be excluded from the mineral during the experiment, and when this is the case the outer flame is used. The outer is called the oxidizing flame (because oxygen, one of the constituents of the atmosphere, combines in many cases with some parts of the assay, or substance under experiment), and the inner the reducing flame. In the latter the carbon and hydrogen of the flame, which are in a high state of ignition, and which are enclosed from the atmosphere by the outer flame, tend to unite with the oxygen of any substance that is inserted in it. Hence substances are reduced in it.

The mineral is supported in the flame either on charcoal; or by means of steel forceps (as in the annexed figure) with plati-

num extremities (ab), opened by pressing on the pins $p p$; or on platinum wire or foil.

To ascertain the fusibility of a mineral, the fragment for the platinum forceps should not be larger than the head of a pin, and, if possible, should be thin and oblong, so that the extremity may project beyond the platinum. The fusible metals alloy readily with phatinum. Hence compounds of lead, arsenic, antimony, etc., must be guarded against. Theso compounds are tested on charcoal. The forceps should not be used with the fluxes, but instead either oharcoal or the platinum wire or foil.

The charcoal should be firm and well burnt; that of soft wood is the bost. It is employed especially for the reduction of oxides, in which the presence of carbon is often necessary, and also for observing any substances which may pass off and be deposited on the charcoal around the assay. These coatings are usually oxides of the metals, which are formed by the oxidation of the volatile metals as they issue from the reduction flame.

The platinum wire is employed in order to observe the action of the fluxes on the mineral, and the colors which the oxides impart to the fluxes when dissolved in them. The wire used is No. 27. This is cut into pieces about three inches long, and the end is bent into a small loop, in which the flux is fused. This makes what is called a bead. When the experiment is complete the beads are removed by uncoiling the loop and drawing the wire through the finger nails. After use for awhile the end breaks off, because platinum is acted upon by the soda, and then a new loop has to be made. Dilute sulphuric acid will remove any of the flux that may remain upon it after a trial has been made.

Glass tube is employed for various purposes. It should be from a line to a fourth of an inch in bore. It is cut into pieces four to six inches long, and used in some cases with both ends open, in others with one end closed. In the closed tube, either heated directly over the Bunsen burner, or with the aid of the blowpipe, volatile substances in the assay are vaporized and condensed in the upper colder part of the tube, where they may be examined by a lens if necessary, or by further heating. The odor given off may also be noted, and the acidity of any fumes by inserting a small strip of litmus paper in the mouth of the tube. The closed tube is used to observe all the effects that may take place when a substance is heated out of contact with the air. In the open tube the atmosphere passes through the tube in the heating, and so modifies the result. The assay is placed an inch or an inch and a quarter from the lower end of the tube; the tube should be hold nearly horizontally, to
prevent the assay from falling out. The strength of the draught depends upon the incluation of the tube, and in special cases it should be inclined as much as possible.

The most common fluxes are borax (sodium bi-borate), salt of phosphorus (sodium and ammonium phosphate), and soda (sodium carbonate, either the carbonate or bi-carbonate of soda of the shops.) These substances, when fused and highly heated, are very powerful solvents for metallic oxides. They should be pure preparations. The borax and soda are much the most important. In using the platinum wire, the loop may be highly heated, and then a portion of the borax or soda may be taken up by it, and by successive repetitions of this process the requisite amount of the flux may be obtained on the wire. Then, by bringing the melted flux of the loop into contact with one or more grains of the pulverized mineral, the assay is madt ready for the trial. With soda and quartz a perfectly clear globule is obtained, cold as well as hot, if the flux is used in the right proportion. Some oxides impart a deep and characteristic color to a bead of borax. In other cases the color obtained is more characteristic when salt of phosphorus is employed. The color obtained in the outer flame is often different from that which is obtained in the inner flame. The beads are sometimes transparent and sometimes opaque. If too much substance is employed the beads will be opaque when it is desired that they should be transparent. In such cases the experiment may be repeated with less substance. In many cases pulverized mineral and the flux, a little moistened, are mixed together into a ball upon charcoal, especially in the experiments with soda.

In the examination of sulphides, arsenides, antimonides and related ores, the assay should be roasted before using a flux, in order to convert the substance into an oxide. This is done by spreading the substance out on a piece of charcoal and exposing it to a geutle heat in the oxidizing flame. The sulphur, arsenic, antimony, etc., then pass off as oxides in the form of vapors, leaving the non-volatile metals behind as oxides. The escaping sulphurous acid gives the ordinary odor of burning sulphur; arsenous acid, from arsenic present, the odor of garlic, or an alliaceous odor; selenous acid, from selenium present, the odor of decaying horse-radish; while antimony fumes are dense white, and have no odor.

The following is the scale of fusibility which hes been adopted, beginning with the most fusible:

1. Stibnife.-Fusible in large pieces in the candle flame.
2. Natrolite.-Fusible in small splinters in the candle flame.
3. Almandine, or bright red garnet.-Fusible in large pieces with ease in the blowpipe flame.
4. Actinolite.-Fusible in large pieces with difficulty in the blowpipe flame.
5. Orthoclase, or common feldspar. Fusible in small splinters with difficulty in the blowpipe flame.
6. Bronzite.-Scarcely fusible at all.

The color of the flame is an important character in connection with blowpipe trials. When the mineral contains sodium the color of the flame is deep yellow, and this is generally true in spite of the presence of other related elements. When sodium (or soda) is absent, potassium (or potash) gives a pale violet color; calcium (or lime) a pale reddish yellow; lithium, a deep purple-red, as in lithia-mica; strontium, a bright red, this element being the usual source of the red color in pyrotechny; copper, emerald green; phosphates, bluish green; boron, yellowish green; copper chloride, azure blue. Beads should be examined by daylight only, and shonld be held in such position that the color is not modified by green trees or other bright objects when examined by transmitted light. Colored flames are seen to best advantage when some black object is beyond the flamo in the line of vision.

It is also to be noted, in the trials, whether the assay heats up quietly, or with decrepitation; whether it fuses with effervescence or not, or with intumescence or not; whether it fuses to a bead which is transparent, clouded, or opaque; whether blebby (containing air-bubbles or not); whether scoria-like or not.

Testing for Water.-The powdered mineral is put at the bottom of a closed glass tube, and after holding the extremity for a moment in the flame of a Bunsen's burner, moisture, if any is present, will have escaped and be found condeused on the inside of the tube, above the heated portion. Litmus or turmeric paper is used to ascertain if the water is acid or alkaline, acids changing the blue of litmus paper to red, and alkalies the yellow of turmeric paper to brown.

Testing for an Alkali.-If the fragment of a mineral, heated in the platinum forceps, contains an alkali, it will often, after being highly heated, give an alkaline reaction when placed, after moistening, on turmeric paper, turning it brown. This test is applicable to those salts which, on heating, part with a portion of their acid and are rendered caustic thereby. Such
are the carbonates, sulphates, nitrates, and chlorides of the alkaline metals.

Testing for Alumina or Magnesia.-Cobalt nitrate, in solution, is used to distinguish an infusible and colorless mineral containing aluminium from one containing magnesium. A fragment of the mineral is first ignited, and then wet with a drop or two of the cobalt solution and heated again. The aluminium mineral will assume a blue color, and the magnesium mineral a pale red or pink.

Any fusible silicate, when moistened with cobalt nitrate and ignited will assume a blue color, hence this test is only decisive in testing infusible substances.

Infusible zinc compounds, when moistened with cobalt nitrate, assume a green color.

Testing for Lithium.-Some lithium minerals give the bright purple-red flame if simply heated in the platinum forceps. In other cases mix the powdered mineral with one part of fluorite and one of potassium bi-sulphate. Mako the whole into a paste with a little water, and heat it on the platinum wire in the blue flame.

Testing for Boron.-When the bright yellow-green of boron is not obtained directly on heating the mineral containing it, one part of the powdered mineral should be mixed with one part of powdered fluorite and three of potassium bi-sulphate; and then treated as in the last. The green color appears at the instant of fusion.

Testing for Pluorine.-To detect fluorine in fluorides mix a little of the powdered substance with potassium bi-sulphate, put the mixture in a closed glass tube and fuse gently. The li-sulphate gives off half of its sulphuric acid at a high temperature, which acts powerfully on anything it can attack. If a fluoride is present, hydrofluoric acid will be given off, and the walls of the tube will be found roughened and etched when the tube is broken open and cleaned after the experiment. If a silicate containing fluorine be powdered and mixed with previously fused salt of phosphorns, and heated in the open tube by blowing the flame into tho lower end of the tube, hydrofluoric acid is given off, and the tube is corroded just above the assay.

Silicates.-Nearly all silicates undergo decomposition with salt of phosphorus, setting free the silica, forming a bead which is clear while hot aud has a skeleton of silica floating in it. The bead is sometimes clear also when cold.

Iron.-Minerals containing much iron produce a magnetic globule when highly heated. Usually the reducing flame is
required, and sometimes the use of soda. With borax iron gives a bead with the oxidizing flame which is yellow while hot, but colorless on cooling, and which in the reducing flame becomes bottle green.

Cobalt.-Minerals containing cobalt afford, with borax, a beautiful blue bead. If sulphur or arsenic is present it should be first roasted off on charcoal.

Nickel.-In the oxidizing flame with borax, the bead is violet when hot, and red-brown on cooling. In the reducing flame the glass becomes gray and turbid from the separation of metallic nickel, and on long blowing, colorless. The reaction is obscured by the presence of cobalt, iron, and copper.

Manganese.- With borax in the oxidizing Hame, the bead is a deep violet-red, and almost black if too much of the mineral is used. To see the color examine by transmitted light. With soda in the same thame the opaque bead is bluish green.

Chromium.-With borax, both in the oxidizing and reducing flame, the bead is hright emerald green.

Titanium. -Titanium oxide with salt of phosphorus on platinun wire in O.F. dissolves to a clear glass, which, if much is present, becomes yellow while hot and colorless on cooling; but in R.F. the hot globule obtained in O.F. reddens and assumes finally a beautiful violet color. On charcoal with tin the glass becomes violet if there is not too much iron present.

Zinc.-Zine and some of its compounds when heated cover the charcoal with zinc oxide, which is yellow while hot, but white on cooling; and this coating, if wet with cobalt solution and then heated, assumes a fine yellowish-green color which is most distinct when cold.

Lead, copper, tin, silver, when characterizing a mineral, give with soda in the reducing flame minute metallic globules, which are malleable, or may be cut with a knife; they can be distinguished by their well-known physical properties. When two or more of these metals occur together, or iron is also present, the globules consist usually of an alloy of the metals.

Lead.-When the mineral is treated with soda on charcoal in the oxidizing flame, the yellow oxide coats the charcoal around the assay.

Copper.-The flame is colored, in most cases, bright green. With borax or salt of phosphorus in the reducing tlame the bead is red. In the oxidizing flame the bead is green when hot and becomes blue or greenish blue on cooling.

Mercury.-Heated in the closed tube with soda, a sublimate of metallic mercury covers the inside of the tube.

Silver.-If the silver is in very small quantities, as in argentiferons galena, the assay is put into a little cup made of bone ashes (bone burnt white and finely pulverized), and subjected to the oxidizing flame; the lead is oxidized and sinks into tho bone ashes, leaving the silver a brilliant globule on the cupel. Before cupellation it is often necessary to melt the assay together with some borax and pure lead in a hole on charcoal. By this process the sand and impurities are removed, and a globule of lead is obtained which contains all the silver, and which may be separated from the slag and be oxidized as above.

Arsenic.-In the closed tube arsenic sublimes and conts the tube with brilliant grains, or a crust, of metallic arsenic. If the mineral contains sulphur as well as arsenic, sublimates of the yellow and red arsenic sulphides (orpiment and realgar) are often formed. In the open tube a sublimate of white arsenous acid is formed, which condenses in bright crystals on the walls of the tube, and a strong garlic odor is given off. On charcoal the alliaceous odor is at once perceptible.

Antimeny.-In the closed tube, when sulphur is present, the assay yields a sublimate which is black when hot, brown-red when cold. In the open tube dense white vapors are given off and a white amorphous sublimate covers the inside of the tube, which, for the most part, does not volatilize when reheated. On charcoal the assay yiclds dense, white, inodorous fumes.

Tellurium.-In the open tube a white or grayish sublimate is obtained, which may be fused to clear, colorless drops. On charcoal a white coating is produced, and the reducing flame is colored green.

Sulphur.-All sulphates, and other sulphur-bearing minerals, when heated on charcoal with soda, produce a dark, yellowish brown sulphide of sodium; and if a fragment of this is moistened and placed on a polished plate of silver, it turns it immediately brownish black, or black. Pure soda, and a thame wholly free from sulphur, is needed for the trial, since the least trace of sulphur in either vitiates the result. Many sulphides give fumes of sulphur on charcoal. The higher sulphides afford these fumes in a closed tube. The others afford fumes of sulphurous acid in an open tube, which redden a moistened blue litmus paper placed in the upper end of the tube.

Selenium.-Selenium and many sclenides afford a steel-gray sublimate in an opon tube, which at the upper edge appears red. On charcoal brown fumes are given off with an odor like that of decaying horse-radish.

Chlorides. - If a bead of borax be saturated with copper oxide, and then dipped into the powder of a substance which is to be tested for chlorine, a chloride of copper is formed which imparts an azure blue color to the flame if any chlorine is present. If dissolved in water or nitric acid a little silver nitrate produces a dense white precipitate of silver chloride.

Nitrates.-A nitrate, if fused on charcoal, will deflagrate with brilliancy, owing to the decomposition of the nitrate and the union of its oxygen with the carbon.

Phosphates.-Phosphates give a dirty green color to the blowpipe flame. The color is more distinct if the substance is first moistened with sulphuric acid. If a phosphate is pulverized and heated in a closed glass tube with some bits of magnesium wire, the phosphoric acid is reduced, and when the fusion is moistened with water the very disagreeable odor of phosphuretted hydrogen is obtained.

For a full account of blowpipe reactions recourse must be had to a treatise on the blowpipe. The best and fullest American work on the subject is Prof. G. J. Brush's "Manual of Determinative Mineralogy, with an Introduction on Blowpipe Analysis."

In this work the following abbreviations are used in speaking of blowpipe reactions:
B.B. $=$ before the blowpipe; O.F. = oxidizing flame; In. $F^{\prime}$. = reducing flame.

## 4. DESCRIPTIONS OF MINERALS.

## Classification.

Some of the prominent points in the classification of minerals adopted in the following pages are given in connection with the remarks on chemical composition, pages 79.

Many instructors in the science, and most of those who consult a work on Mineralogy for practical purposes, prefer an arrangement of the ores which groups them under the head of the metal prominent in their constitution. The method of grouping mineral species according to the basic element has therefore been here, to a large extent, followed. An exception has been made in the case of the silicates, because it is with them almost impracticable, on account of the number of basic elements they often contain; and, moreover, not more than half a dozen useful ores exist among them. The silicates therefore, which include the larger part of all minerals, make together one of the grand divisions in the classification, and they are presented according to their natural groups, in the same order as in the larger mineralogy.

The prominent subdivisions in the classification are as follows:
I. The Acidic division, including the acidic elements occurring native, and the native compounds of the acidic elements with one another.
II. The Basic division, including the basic elements occurring native, and the native binary and ternary compounds of the basic elements-the silicates excepted.
III. Silica and the Silicates.
IV. The Hydrocarbon Compounds, including mineral oils, resins, wax, and coals.

The following are the chief subdivisious under these heads:

## I. Acidic Division.

1. Sulphur Group.-The chief oxide a trioxide, its formula $\mathrm{RO}_{3}$. Includes Sulphur and sulphur oxides; Tellurium and tellurium oxides; Molybdonum sulphide and oxide; Tungsten oxide.
2. Boron Group.-The chief oxide a trioxide, its formula $\mathrm{R}_{2} \mathrm{O}_{3}$. Includes compounds of Boron with oxygen.
3. Arsenic Group.-The chief oxide a pentoxide, its formula $\mathrm{R}_{\mathrm{y}} \mathrm{O}_{\mathrm{b}}$. Includes Arsenic and arsenic sulphides and oxides; Antimony and antimony sulphide, arsenide and oxides; Bismuth and bismuth sulphide, telluride and oxide.
4. Carbon Group.-The chief oxide a dioxide, its formula R ( $r_{2}$. Includes Carbon (Diamond, Graphite) and carbon dioxide. (Quartz, Si $\mathrm{O}_{2}$, belongs here chemically, but is placed with the Silicates.)

## II. Basic Division.

Gold; Silver; Platinum and Iridium ; Palladium; Quicksilver ; Copper; Lead ; Zinc ; Cadmium ; Tin ; Titanium ; Cobalt and Nickel ; Uranium ; Iron; Manganese; Aluminium ; Cerium, Yttrium, Lanthanum, Didymium and Erbium; Magnesium; Calcium; Barium and Strontium; Potassium and Sodium; Armonium ; Hydrogen.

## IlI. Silica and Silicates.

1. Silica.
2. Anlydrous Silicates.
3. Bisilicates.
4. Unisilicates.
5. Subsilicates.
6. Hydrous Silicates.
7. General section of Hydrous Silicates.
8. Zeolite section.
9. Margarophyllite section.

## IV. Hydrocarbon Compounds.

1. Oils, Resins, Wax.
2. Asphaltum, Coals.

## General Remaris on Ores.

An ore, in the mineralogical sense of the word, is a mineral compound in which a metal is a prominent constituont. In the
miner's use of the term it is a mineral substance that yields, by metallurgical treatment, a valuable metal, and especially when it profitably yields such a metal. In the former sense, galena, the common ore of lead, is, if it contains a little silver, an argentiferous lead-ore; while, in the latter, if there is silver enough to make its extraction profitable, it is a silver-ore. Further than this, where a native metal, or other valuable metallic mineral, is distributed intimately through the gangue, the mineral and gangue together are often called the ore of the metal it produces.

We have beyond to do with ores only in the mineralogical sense.

Ores are compounds of the metals, not metals in the native state. The more common kinds are compounds of the metals with Sulphur (sulphides); with Arsenic (arsenides) ; with Sulphur and Arsenic (sulph-arsenides) ; with sulphur in ternary combination along with arsenic, antimony or bismuth (making compounds called sulph-arsenites, sulph-antimonites, sulpho-bismutites) ; with Selenium (selenides); with Tellurium (tellurides) ; with Oxygen (oxides) ; with Chlorine, Iodine, or Bromine (chlorides, iodides, or bromides); with oxygen in ternary combination with carbon (making carbonates); with Sulphur (making sulphates); with Arsenic (making arsenates) ; with Phosphorus (making phosphates); with Silicon (making silicates).

Gold and platinum are, with rare exceptions, found only native, or intimately mixed in essentially the pare state with some metallic minerals. Tellurium is the only acidic element that occurs combined with gold in nature.

Silver is found in the state of sulphide, antimonide, selenide, telluride, sulph-arsenites and sulph-antinionites, but never as oxide or in oxygen ternary compounds.

Quicksilver occurs in the state of sulphide (the common ore) ; also in that of selenide and sulph-arsenites.

Copper and lead occur in the state of sulphides (common ores), and also in all the binary and ternary states mentioned above.

Zinc is known in the state of sulphide (very common), oxide, carbonate, sulphate, silicate (all, excepting the sulphate, valuable as ores); and Cadmium in that of sulphide only.

Tin occurs in the state of oxide (the common ore), and sulphide.

Cobalt and Nickel occur in the states of sulphide, arsenide, sulph-arsenides, antimonide, oxide, sulphate, arsenate, carbouate; and nickel in that also of a silicate.

Iron occurs in the state of sulphide (very common, but not useful as an ore of iron), of arsenide, sulph-arsenide, oxide (the common ores of iron), carbonate (useful ore), sulphate, arsenate, phosphate, silicate.

Manganese occurs in the state of sulphide (rare), arsenide (rare), oxide (the common ores), carbonate, sulphate, phosphate, silicate.

## I. MINERALS CONSISTING OF TIIE $\Lambda$ CIDIC ELEMENTS.

Oxygen might properly be included in this section, since it occurs native in the atmosphere mixed with nitrogen, constituting 21 per cent. of it. But this mention of it is all that is necessary. The ternary compounds, in which, as in sulphuric acid, hydrogen is the basic element, are here included. Chlorine, bromine, and iodine do not occur native, and neither do their oxides, nor any compounds with acidic elements, and hence these elcments are not represented under this division. The same is true of selenium and chromium of the sulphur group, and of vanadium, tantalum, and columbium of the arsenic group.

## I. SULPHUR GROUP.

## Native Sulphur.

Trimetric.-In acute octahedrons, and secondaries to this form, with imperfect octahedral cleavage. $1 \wedge 1$ (in same pyra-

mid) $=106^{\circ} 25^{\prime}$ and $85^{\circ} 07^{\prime} ; 1 \wedge 1$ (over base) $=143^{\circ} 23^{\prime}$. Also massive.

Color and streak sulphur-yellow, sometimes orange-yellow.

Lustre resinous. Transparent to translucent. Brittle. H. = $1 \cdot 5-2 \cdot 5$. G. $=2.07$. Burns with a blue flame and sulphurous odor. In a closed tube it is wholly volatilized and redeposited on the wall of the tube.

Native sulphur is either pure, or contaminated with clay or bitumen. It sometimes contains selenium, and has then an orange-yellow color.

Diff. It is easily distinguished by its burning with a blue flame, and the sulphur odor then afforded.

Obs. The great repositories of sulphur are either beds of gypsum and the associate rocks, or the regions of active or extinct volcanoes. In the valley of Noto and Mazzaro in Sicily, at Conil near Cadiz in Spain, Bex in Switzerland, and Cracow in Poland, it occurs in the former situation. Sicily and the neighboring volcanic islands, Vesuvins and the Solfatara in its vicinity, Lceland, Teneriffe, Java, Hawaii, New Zealand, Deception Island, and most active volcanic regions afford more or less sulphur. The native sulphur of commerce is brought largely from Sicily, where it occurs in beds along the central part of the south coast and to some distance inland. It undergoes rough purification by fusion before exportation, which separates the earth and clay with which it occurs.
: On the Potomac, twenty-five miles above Washington, sulphur has been found associated with calcite in a gray compact limestone; sparingly about springs where hydrogen sulphide is evolved, in New York and elsewhere; in cavities where iron sulphides have decomposed, and in many coal mines; near Borax Lake, in California; Inferno, Humboldt County, Nevada, abundant.

The sulphur of commerce is also largely obtained from copper and iron pyrites, it being given off during the roasting of these ores.

Sulphur when cooled from fusion, or above $232^{\circ} \mathrm{F}$., crystallizes in oblique rhombic prisms. When poured into water at a temperature above $300^{\circ} \mathrm{F}$. it acquires the consistency of soft wax, and is used to take impressions of gems, medals, etc., which harden as the sulphur cools. The uses of sulphur for gunpowder, bleaching, the manufacture of sulphuric acid, and also in medicines, are well known. Sulphur occurs in various ores as sulphides and sulphates. Among the sulphides are pyrite, au iron sulphide; pyrrhotite, another iron sulphide; galena, a lead sulphide, the common ore of lead; chalcopyrite, or yellow copper ore, a copper and iron sulphido; cinnabar, a mercury sulphide; argentite, a silver sulphide, etc.

## Sulphuric and Sulphurous Acids.

Sulphuric acid is occasionally met with around volcanoes, and it is also formed from the decomposition of hydrogen sulphide about sulphur springs.

It is intensely acid. Composition, Sulphur teroxide ( $\mathrm{SO}_{3}$ ) $81 \cdot 6$, water $18 \cdot 4=100$, it being chemically hydrogen sulphate. Occurs in the waters of Rio Vinagre, South America; also in Java, and at Lake de Taal on Luzon, in the East Indies ; in Genesce Co., N. Y. ; and at Tuscarora, St. Davids, and elsewhere, Canada West.

Sulphurous acid, or sulphur dioxide $\left(\mathrm{SO}_{2}\right)$, is produced when sulphur burns, and causes the odor perceived during the combustion. It is common about active volcanoes. It destroys life and extinguishes combustion. Composition, Sulphur $50 \cdot 00$, oxygen $50 \cdot 00$.

## Native Tellurium.

Hexagonal ; $R \wedge R=80^{\circ} 5 \%^{\prime \prime}$. Occurs sometimes in six-sided prisms with perfect lateral cleavage; but is commonly granular massive. Color and strcak tin-white. Brittle. II. $=2-2 \cdot 5 . \quad$ G. $=6 \cdot 1-6 \cdot 3$.

Sometimes contains a little iron, and also a trace of gold. In an open tube, B.B. yields a white inodorous sublimate, which may be fused to colorless transparent drops ; and on charcoal fuses and volatilizes, tinging the flame green, and covering the charcoal with white tellurium dioxide.

Obs. Occurs in Hungary and Transylvania; also, Boulder Co., Colorado, at the Red Cloud Mine; in Magnolia District at the Keystone, Dun River, and other mines; in the Ballerat District at Smuggler Mine; in Central District at the John Jay Mine, where masses of 25 pounds weight are reported to have been found.
Tellurium is also a constituent of ores of silver and lead (pp. 118, 149), and these are the chief sources of the metal.

Tellurite or Tellurons acid, $\mathrm{TeO}_{2}$, occurs at the Keystone, Smuggler, and John Jay Mines; especially the last, where it is in minute white or yellowish crystals having one eminent cleavage.

Molybdenite.-Molybdenum Sulphide.
Hexagonal. In hexagonal plates, or masses, thin foliated, like graphite, and resembling that mincral. $H .=1-1 \cdot 5$. G. $=4 \cdot 45-4 \cdot 8$. Color pure lead-gray; streak the same,
slightly inclined to green. Thin lamine rery flexible ; not elastic; leaves a trace on paper, like graphite, but its coler is slightly different, being bluish-gray.

Composition. $\mathrm{MoS}_{2}=$ Sulphur $41 \cdot 0$, molybdenum $59 \cdot 0=$ 100. B.B. infusible, but when heated on charcoal, sulphur fumes are given off, which are deposited on the coal. Dissolves in nitric acid, excepting a gray residuc.

Diff. Resembles graphite, but differs in its paler color and streak, and also in giving fumes of sulphur when heated, as well as by its solubility in nitric acid.

Obs. Occurs in granite, gneiss, mica schist, and allied rocks; also in granular limestone. It is found in Sweden, at Arendal in Norway, in Saxony, Bohemia, at Caldbeck Fell in Cumberland, and in the Cornish mines.

In the United States it occurs in Maine at IBlue IIill Bay, Camdage Farm, Brunswick, and Bowdoinham ; in New Hampshire at Westmoreland, Landaff, and Franconia; in Massachusetts at Shutesbury and Brimfield ; in Connecticut at Haddam and Saybrook; in New York near Warwick; in New Jersey near the Franklin Furnace.

Molybdenum does not occur native. An oxide is occasionally found in yollow incrustations on molybdenite, as a result of its alteration. It occurs, combined with lead, as a molybdate (page 151), and this is the only native salt containing it. The name molybdenum is from the Greek molubdaina, meaning mass of lead, and alludes to the resemblance of molybdenite to graphite.

Tungstite, or Tungstic ochre. A vellow powder or incrustation occurring with wolfram, and a result of its decomposition. Occasionally observed at Lane's Mine, Monroe, Conn.
Besides this oxide there are the nativo compounds, iron tungstate or wolfram (p. 183), lead tungstate (p. 151), and calcium tungstate. Tungsten also occurs sparingly in some ores of columbium, as in certain varieties of the minerals pyrochlore, columbite, and yttro-columbite.

## II. BORON GROUP.

In Boron, as in the Sulphur group, the most prominent oxide is a teroside.

> Sassolite.-Boracic Acid. Sassolin.

Occurs insmall scales, white or yellowish. Feel smooth and unctuous. Taste acidulous and a little saline and bitter.
G. $=1.48$. Composition, $\mathrm{H}_{6} \mathrm{O}_{8} \mathrm{Bo}_{2}=$ Boron teroxide 56.4 , water $43 \cdot 6$. It is stricily hydrogen borate. Fuses easily in the flame of a candle, tinging the flame at first green.

Found at the crater of Vulcano, and also at Sasso in Italy, whence it was called Sassolin. The hot vapors of the lagoons of Tuscany afford it in large quantities. The vapors are mado to pass through water, which condenses them ; and the water is then eraporated by the steam of the springs, and boracio acid obtained in large crystalline flakes. It still requires purification, as the best thus procured contains but 50 per cent. of the pure acid. Occurs also in the waters of Lick Springs, Tchama Co., and Borax Lake, Lake Co., California, where it was first observed, through their evaporation, by Dr. J. A. Vatch, in 1886. It has since been obtained from the waters of Mono, Owens, and other lakes. It exists sparingly in the waters of the ocean. But in all these waters, it is probably in combination.
Borm occurs usually in the condition of magnesium, calcium, and sodium borates ( $\mathrm{pr} .206,212,227$ ) ; and rarely as an iron borate (p. 182), or ammonium borate ( $\mathbf{p}$. 231). It also occurs in the silicates, tourmaline, danburite, axinite, and datolite, in which it is easily detected by the blowpipe reaction (p. 87).

## III. THE ARSENIC GROLP.

The elements of the Arsenic group occurring among minerals are, arsenic, antimony, bismuth, phosphorus, nitrogen, vanadium, tantalum, columbium. Of these arsenic, antimony, and bismuth occur native, and as sulphides; also, in combination with other metals, constituting arsenides, antimonides, bismutides; and, along with sulphur also, making sulpharsenites, sulphantimonites, sulphlismutites. In addition, they all, excepting bismuth, enter into the constitution of a series of native ternary oxygen compounds or salts, called severally, arsenates, antimonates, phosphates, nitrates, vanadates, tantalates, columbates.

The chicf oxide has the gencral formula $\mathrm{R}_{2} \mathrm{O}_{3}$.

## Native Arsenic.

Rhombohedral. $R \wedge R=85^{\circ} 41^{\prime}$. Cleavage basal, imperfect. Also massive, columnar, or granular.

Color and streak tin-white, but usually dark grayish from tarnish. Brittle. H. $=3 \cdot 5$. G. $=5 \cdot 65-5 \cdot 95$.
B.B. volatilizes very readily before fusing, with the odor of garlic; also burns with a pale bluish tlame when heated just below redness.

Obs. Occurs with silver and lead ores. It is found in considerable quantities at the silver mines of Freiberg and Schneeberg; also in Bohemia, the Hartz, at Kapnik in Upper IIungary, in Siberia in large masses, and elsewhere.

In the United States it has been observed at Maverhill and Jackson, N. II., and at Greenwood, Me.

## Orpiment-Yellow Arsenic Sulphide.

Trimetric. Cleavage highly perfect in one direction. In foliated masses, and sometimes in prismatic crystals. Color and streak fine yellow. Lustre brilliant pearly, or metallic pearly, on the face of cleavage. Subtransparent to translucent; sectile. H. $=1 \cdot 5-2 . \quad$ (.$=3 \cdot 4-3 \cdot 5$.

Composition. $\mathrm{As}_{2} \mathrm{~S}_{3}=$ Sulphur $39 \cdot 0$, arsenic $01 \cdot 0$. Wholly evaporates before the blowpipe with an alliaceous odor, and on chareon hurns with a blue flame.

From ILungary, Koordistan in Turkey in Asia, China, and South Arnerica. Occurs at Edenville, N. Y., as a yellow powder, resulting from the decompositon of arsenical iron.
is another arsenic sulphide. It has a fine clear red color, aurora red to orauge, and occurs transparent or translucent ; H. = $15-2$; G. $=3 \cdot 35-3 \cdot 65$; Composition, As $\mathrm{S}=$ Sulphur $29 \cdot 9$, arsenic $70 \cdot 1$. Like the preceding before the blowppe. From Hungary, Bohemia, Saxony, the Hartz, Switzerland, and Koordistan in Asiatic Turkey. It has been observed in the lavas of Vesuvius.

Reulgar is one of the ingredients of white Indian fire, often used as a signal light. Orpiment is a coloring ingredient in the pigment called king's yelloo, in which it is mixed with arsenious acid.

## Arsenolite.-White Arsenic.

Isometric. In minute capillary crrstals, and botryoidal or stalactitic. Color white. Soluble; taste astringent, sweetish. $\mathrm{H} .=1 \cdot 5 . \quad(\mathrm{x} .=3 \cdot \%$.

Composition. $\mathrm{As}_{2} \mathrm{O}_{3}=$ Arsenic $75 \cdot 8$, oxrgen $24 \cdot 2=100$.
This is the same compound with the common arsenic of the shops. It is found but sparingly native, accompanying ores of silver, lead, and arsenic in the Hartz, Bohemia, and elsewhere. It is a well-known poison.

Claudetite is the same compound in trimetric crystallizations, from Portagal.

General Remarks-Arsenic is obtained for commerce chiefly from arsenopyrite (ormispickel), an iron sulph-arsenide, and from the nickel and cobalt arsenides, by first roasting off the sulphur, and then condensing the arsenic, in the state of $\mathrm{As}_{2} \mathrm{O}_{3}$ (" arsenous acid") in large chambers. To obtain the material pure it is usually sublimed again in iron pots, in the upper part of which (artificially kept cool) it is condensed, mostly in a half-fused vitreous condition. To reduce the oxide to the metallic state it is heated with charcoal. In Devon and Cornwall the arsenical ores occur with the tin ore, and a large amount of white arsenic is made. The metal arsenic forms a small part of some alloys; the most important is that with lead for shot making.

## Native Antimony.

Rhombohedral ; $R \wedge R=87^{\circ} 35^{\prime}$. Usually massive, with a very distinct lamellar structure ; sometimes granular. Color and streak tin-white. Brittle. H. $=3-3 \cdot 5$. G. $=6 \cdot 6-6 \cdot \%$.

Composition. Pure antimony, often with a little silver, iron, or arsenic. B.B. on charcoal fuses easily and passes off in white fumes.

Obs. Occurs in reins of silter and other ores in Dauphiny, Eohemia, Sweden, the Hartz, and Mexico.

Stibnite-Gray Antimony. Antimony Sulphide.
Trimetric. In right rhomlic prisms, with striated lateral faces ; $I \wedge I=90^{\circ} 45^{\circ}$. Clearage in the direction of the shorter diagonal, highly perfect. Commonly diver-
 gent columnar or fibrous. Sometimes massive granular.

Color and streak lead-gray; liable to tarnish. Lustre shining. Brittle ; but thin laminæ a little flexible. Somewhat sectile. H. $=2$. $\mathrm{G} .=4 \cdot 5-4 \cdot 62$.

Composition. $\mathrm{Sb}_{2} \mathrm{~S}_{3}=$ Sulphur $28 \cdot 2$, antimony $71 \%$. Fuses readily in the flame of a candle. B.B. on charcoal it is absorbed, giving off white fumes and a sulphur odor.

Diff. Distinguished by its extreme fusibility and its raporizing before the blowpipe.
Obs. Stibnite occurs in veins with ores of silver, lead, zinc, or iron, and is often aseociated with barite, spathic iron, or quartz. It occurs at Felsöbanya and Schemnitz in IInngary ; at Wolfsberg in the Ifartz; at Brannsdorf near Freiberg; in Auvergne, Cornwall, Spain, and Borneo.

In the United States, it has been found sparingly at Carmel, Me., Lyme, N. H., and at "Soldier's Dclight," Md., in the Ilumboldt mining region, and in the mines of Aurora, Esmeralda County, Nevada.

This ore affords much of the antimony of commerce. By simple fusion, the crude antimony of the shops is obtained, from which pure antimony and its pharmaceutical preparations are made.
Allemontite is an arsenical antimony, $\mathrm{Sb}_{2} \mathrm{As}_{3}$, from Allemont, and niso from Bohemia and the Hartz.

Valentinite. White antimony in white, grayish, or reddish rectangular crystals, with perfect cleavage, affording a rhombic prism of $136^{\prime \prime} 58^{\prime}$. Also in tabular masses, and columnar and granular. $\mathrm{HI}=$ $25-3$. G. $=5.57$. Lustre adamantine to pearly. Composition, $\mathrm{Sb}_{2} \mathrm{O}_{3}$ $=$ Oxygen 16.44, antimony $83 \cdot 56=100$.

Senarmontite is the same compound in isometric forms.
Kormesite or red antimony is an antimony oxide and sulphide, in red tufts of capillary crystals. Lustre adamantine. From Hungary, Dauphiny, Saxony, and the Hartz.

Cervantite. An oxide of antimony, $\mathrm{Sb}_{2} \mathrm{O}_{4}$, resulting from the docomposition of stibnite.
Livingstonite. Like stibnite, but contains 14 per cent. of mercury and has a red strcak. From Mexico.

## Native Bismuth.

Rhombohedral ; $R \wedge R=87^{\circ} 40^{\prime}$. Clcavage rhombohedral, perfect. Generally massive, with distinct cleavage; sometimes granular.

Color and streak silver white, with a slight tinge of red. Subject to tarnish. Brittle when cold, but somewhat malleable when heated. II. $=2-2 \cdot 5 . \quad \mathrm{G} .=9 \cdot \%-9 \cdot 8$. Fuses at a temperature of $476^{\circ} \mathrm{F}$.

Composition. Pure bismuth, with sometimes a trace of arsenic, sulphur or tellurium. B.13. on charcoal vaporizes, and leares a yellow coating on the coal, paler on cooling.

Obs. Native Bismuth is abundant with ores of silver and cobalt in Saxony and Bohemia, and occurs also in Cornwall and Cumberland, England. At Schnceberg, it forms arborescent delineations in brown jasper. Occurs also in Norway, Sweden, Chili and Bolivia; also at the Balhannah mine, in S. Australia, with copper ore and gold.

In the United States, it has been found at Lane's and Booth's mine, Monroe, where it occurs with tungsten, galonite and pyrite; also at Brewer's mine, in Chesterfield district, South Carolina ; and in Colorado.

Bismuthinite. A bismuth sulphide, $\mathrm{Bi}_{2} \mathrm{~S}_{3}$, in acicular crystals of a lead-gray color.

Guanajuatite. A bismuth selenide, from Guanajuato, Mexico, called also frenzelite. Silaonite is a selenide from the same locality, of a lead-gray color.

Bismite. Bismuth ochre, an impure oxide, grayish, to greenish and yellowish white, and massive or earthy, found with native bismuth.

## Tetradymite.-Bismuth Telluride.

Hexagonal ; $R \wedge R=81^{\circ} 2^{\prime}$. Crystals often tubular, with a verv perfect basal cleavage. Also massive, and foliated or granular. Laminæ flexible, and soil paper. Lustre splendent metallic. Color pale steel-gray, a little sectile. II. $=1 \cdot 5-2 . \quad$ G. $=7 \cdot 2-7 \cdot 9$.

Composition. Consists of bismuth and tellurium, with sometimes sulphur and selenium, affording for the most part the formula $\mathrm{Bi}_{2}(\mathrm{Te}, \mathrm{S})_{3}$. A variety from Dahlonega, Georgia, gave Tellurium $48 \cdot 1$, bismuth $51 \cdot 9=\mathrm{Bi}_{2}{ }^{2} \mathrm{Te}_{3}$; $\mathrm{G}_{.}=7 \cdot 642$. Joseite is a bismuth telluride from Brazil, in which half the bismuth is replaced by sulphur ; and Wehrlite is another containing sulphur, from Deutsch Pilsen, Hungary, having $\mathrm{G}=8 \cdot 44$.

Obs. Found with gold in Virginia, North Carolina, and Georgia; Mighland, Montana Territory ; Red Cloud Mine, Colorado ; Montgomery Mine, Arizona.

General Remarks. - The metal bismuth is obtained mostly from native bismuth. Besides the above ores, there are also others in which the metal is combined with silver, lead, and cobalt (pp. 116, 166); and a carbonate of bisinuth, which occurs rarely in connection with native bismuth or the ores of the metal, as a result of oxidation; also a silicate.

## IV. CARBON GROUP.

The Carbon group in chemistry comprises carbon and silicon, in which the formula for the most prominent oxide is $\mathrm{R} \mathrm{O}_{2}$. Only carbon occurs native.

Carbon occurs crystallized in the diamond and graphite ; as oxides, in carbon oxide, and carbon dioxide (ordinarily called carbonic acid); combined with hydrogen, or hydrogen and oxygen, in bitumen, mineral oils, amber, and a number of native mineral resins, and mineral wax; and as the chief constituent of mineral coal, in which it is combined
with more or less of hydrogen and oxygen and usually some nitrogen.

## Diamond.

Isometric. In octahedrons, dodecahedrons and more complex forms. Faces often curved, as in the figures. Cleavage octahedral ; perfect.


Color white, or colorless ; also yellowish, red, orange, green, blue, brown or black. Lastre adamantinc. Transparent ; translucent when dark-colored. II. $=10$. (.$=$ $3 \cdot 48-3 \cdot 5 \%$.

Composition. Pure carbon. It lurns and is consumed at a high temperature, producing carbonic acid gas. Exhibits vitreous electricity when rubbed. Some specimens exposed to the sun for a while, give out light when carried to a dark phace. Strongly refracts and disperses light.

Diff. Diamonds are distinguished hy their superior hardness; their brilliant reflection of light and adamantine lustre, their vitreous electricity when rubbed, which is not afforded by other gems unless they are polished; and, by the practiced car, by means of the sound when rubbed together.

Obs. The coarse diamonds, unfit for jewelry, are called bort, and the kind in black pebbles, or masses, from Brazil, carbonado. The latter oceur sometimes in pieces 1,000 carats in weight ; they have $\mathrm{G} .=3$ to $3 \cdot 42$. Another kind is much like anthracite, $\mathrm{C} .=1 \cdot 66$, although as hard as diamond crystals ; it is in globules or mammillary masses, often partly made up of concentric layers.

Diamonds occur in India, in the district between Golconda and Masulipatam, and near Parma, in Bundeleund, where some of the largest have been found; also on the Mahanuddy,
an Ellore. In Borneo, they are obtained on the west side. of the Ratoos Mountain, with gold and platina. The Brazilian mines were first discovered in 1728 , in the district of Serra do Frio, to the north of Rio de Janeiro ; the most celebrated are on the river Jequitinhonha, which is called the Diamond River, and the Rio Pardo; seventy to seventy-five thousand carats are exported annually from these regions. In the Urals of Russia they had not been detected till July, 1829, when Humboldt and Rose were on their journey to Siberia. The river Gunil, in the province of Constantine, in Africa, is reported to have afforded some diamonds.
In South Africa, where they were first discovered in 1867, they occur in the gravel of the Vaal River, and in the Orange River country. The value of the diamonds obtained up to Norember, 1875, has been estimated as excecding $60,000,000$ of dollars.
In the United States, the diamond has been met with in Rutherford County, North Carolina; Hall County, Georgia; also Franklin County, North Carolina; in Manchester, opposite Richmond, Virginia; also in Cherokee Ravine, Butte County, Forest Hill in El Dorado County (one weighing nearly $5 \cdot 62$ grains), Fiddletown in Amador County, and in Nevada County, California; and on the coast of Southern Oregon. It has been reported from Idaho.
The original rock in Brazil appears to be either a kind of laminated granular quartz, called itacolumyte; or a ferruginous quartzose conglomerate. The itacolumyte occurs in the Urals, and diamonds have been found in it; and it is also abundant in Georgia and North Carolina. In India, the rock is a quartzose conglomerate. The origin of the diamond has been a subject of speculation, and it is the prevalent opinion that the carbon, like that of coal and mineral oil, is of vegetable or animal origin. Some crystals have been found with black uncrystallized particles or seams within, looking like coal; and this fact has been supposed to indicate such an origin.
Diamonds, with few exceptions, are obtained from alluvial washings. In Brazil, the sands and pebbles of the diamond rivers and brooks (the waters of which are drawn off in the dry season to allow of the work) are collected and washed under a shed, by a stream of water passing through a succession of boxes. A washer stands by each box, and inspectors are stationed at intervals.

Diamonds are valued according to their color, transparency and size. The rose diamond is more valuable than the pure white, owing to the great beauty of its color and its rarity. The green diamond is much esteemed on account of its color. The bluc is prized only for its rarity, as the color is seldom pure. The black diamond, which is uncommonly rare and without beauty, is highly prized by collectors. The brown, gray and yellow varieties are of much less value than the pure white or limpid diamond.

The largest diamond of which we have any knowledge is mentioned by Tavernier, as in the possession of the Great Mogul. It weighed originally 900 carats, or $2, \gamma 69 \cdot 3$ grains, but was reduced by cutting to 861 grains. It has the form and size of half of a hen's egg. It was found in 1550, in the mine of Colone. The diamond which formed the eye of a Braminican idol, and was purchased by the Empress Catherine II. of Russia from a French grenadier who had stolen it, weighs $1944^{3}$ carats, and is as large as a pigeon's egg. The Austrian crown has a diamond weighing 1391 carats. The Pitt or Regent diamond is of less size, it weighing but $136 \cdot 25$ carats, or 4191 grains ; but on account of its unblemished transparency and color, it is considered the most splendid of Indian diamonds. It was sold to the Duke of Orleans by Mr. Pitt, an English gentleman, who was governor of Bencolen, in Sumatra, for $£ 130,000$. It is cut in the form of a brilliant, and is estimated at $£ 125,000$. The Rajah of Mattan has in his possession a diamond from Borneo, weighing 367 carats. The Koh-i-noor, on its arrival in England, weighed $180^{\circ} 016$ carats.* It is said by Tavernier to have originally weighed 7871 carats. It has since been recut and reduced one-third in weight.

In the Dresten Treasury there is an emerald green diamond, weighing $31 \frac{1}{2}$ carats. The IIope diamond, weighing 441 carats, has a beantiful sapphire-blue color.

The diamonds of Brazil are seldom large. Maure mentions one of 120 carats, but they rarely exceed 18 or 20 . One weighing 2542 carats, called the "Star of the South," was found in 1854.

Of South African diamonds, the "Schreiner" weighed,

[^0]in its rough state, 308 carats; and the "Stewart," which has a light straw color, 288.35 carats. The diamonds of South Africa are mostly "off color;" about 10 per cent. are of first quality ; 15, 2d; 20, 3d ; and 55 per cont. are bort ( W . J. Morton). The "Star of South Africa," of pure water, weighed 83.5 carats. Some crystals crack to pieces after being exposed to the air awhile.

The diamond is cut by taking advantage of its clearage, and also by abrasion with its own powder. The flaws are sometimes removed by clearing it. Afterwards the crystal is fixed to the end of a stick of soft solder when the solder is in a half-melted state, leaving the part projecting which is to ho cut. A circular plate of soft iron is then charged with the powder of the diamond, and this, by its revolution, grinds and polishes the stonc. By changing the position, other facets are added in succession till the required form is obtained. Diamonds were first cut in Euroje, in 1456, by Louis Berquen, a citizen of Bruges; but in China and India, the art of cutting appears to have been known at a very curly period.
By the above process, diamonds are cut into brilliant, rose and table diamonds. The brilliant has a crown or upper part, consisting of a large central cight-sided facet, and a series of facets around it; and a collet, or lower part, of pyramidal shapes, consisting of a scries of facets, with a maller series near the base of the crown. The depth of a brilliant is nearly equal to its breadih, and it therefore requires a thick stone. Thinner stones, in proportion to the breadth, are cut into rose and table diamonds. The surface of tho rose diamond consists of a central cight-sided facet of small size, eight triangles, one corresponding to each side of the table, cight trapeziums next, and then a series of sixteen triangles. The collet side consists of a minute central octagon, surrounded by eight trapeziums, corresponding to the angles of the octagon, each of which trapeziums is suldivided by a salient angle into one irregular pentagon and two triangles. The table is the least beautiful mode of cutting, and is used for such fragments as are quite thin in proportion to the breadth. It has a square central facet, surrounded by two or more series of four-sided facets, corresponding to the sides of the square.
Diamonds have also been cut with figures upon them. As early as 1500, Charadossa cut the figure of one of the Futheris of the church on a diamond, for Pope Julius II.

Diamonds are employed for cutting glass ; and for this purpose only the natural edges of crystals can be used, and those with curved faces are much the best. Diamond dust is used to charge metal plates of various kinds for jewelers, lapidaries and others. Those diamonds that are unfit for working, are sold for various purposes, under the name of bort. Drills are made of small splinters of bort, and used for drilling other gems, and also for piercing holes in artificial teeth and vitreous substances generally; and, others of iron set with a few diamonds, for drilling rocks.

## Graphite.-Plumbago.

Ifexagonal. Sometimes in six-sided prisms or tables with a transversely foliated structure. Usually foliated, and massive ; also granular and compact.

Lustre metallic, and color iron-black to dark stecl-gray. Thin laminæ flexible. H. $=1-2 . \quad \mathrm{G} .=2 \cdot 25-2 \cdot 2 \%$. Soils paper, and feels greasy.

Composition. Commonly 95 to 99 per cent. of carbon. B.B. infusible, both alone and with reagents; not acted upon by acids.

Diff. Resembles molybdenite, but differs in being unaffected by the blowpipe and acids. The same characters distinguish the granular varieties from any metallic ores they resemble.

Obs. Graphite (called also black lead) is found in crystalline rocks, especially in gneiss, mica schist and granular limestone; also in granite and argillyte. Its principal English locality at Borrowdale, in Cumberland, is now nearly exhausted.

In the United States graphite occurs in large masses in vems in gneiss at Sturbridge, Mass. It is also found in North Brookfield, Brimfield and Hinsdale, Mass. ; abundant at Roger's Rock, near Ticonderoga; near Fishkill Landing in Dutchess County ; at Rossie, in St. Lawrence County, and near Amity, in Orange County, N. Y. ; at Greenville, N. C.; in Curnwall, noar the Housatonic, and in Ashford, Ct. ; near Attleboro, in Bucks County, Penn.; in Brandon, Vermont ; in Wake, North Carolina; on Tyger River, and at Spartanburg, near the Cowpens Furnace, South Carolina; also abundantly and of excellent quality in Canada, in Buckingham, Fitzroy and Grenville.

For the manufacture of the best pencils the granular graphite was thought necessary, and hence the former great value of the Borrowdale mine, where the texture was peculiarly fine and firm. But now the graphite is ground up, and then compressed under heavy pressure, and thus the fine texture and firmness required may be obtained with any pure graphite. At Sturbridge, Mass., it is rather coarsely granular and foliated, and has been extensively worked. The mines of Ticonderoga and Fishkill Landing, N. Y.; of Brandon, Vt. ; and of Wake, North Carolina, are also worked ; and that of Ashford, Ct., formerly afforded a large amount of graphite, though now the works are suspended.
Graphite is extensively employed for diminishing the friction of machinery; also for the manufacture of crucibles and furnaces ; and as a wash for giving a gloss to iron stoves and railings. For crucibles it is mixed with half its weight of clay.

## Carbonic Acid.

Carbonic acid-carbon dioxide of existing chemistry-is the gas that gives briskness to the Saratoga and many other mineral waters, and to artificial soda water. Its taste is slightly pungent. It extinguishes combustion and destroys life.
Composition. C $_{2}=0 \times \mathrm{xyg}$ en $72 \cdot 35$, carbon $27 \cdot 65=100$.
This gas is contained in the atmosphere, constituting about 4 parts, by volume, in 10,000 parts; and it is present in minute quantities in the waters of the ocean and land. It is given out by animals in respiration, and is one of the results of animal and vegetable decomposition; and from this source the waters derive much of their carbonic acid. This gas is the choke-damp of mines, where it is often the occasion of the destruction of life. It is often present also in wells.
Carbon dioxide (or carbonic acid) is given out by limestone (or calcium carbonate) when it is heated; and quicklime is limestone from which $\mathrm{C}_{2}$ has been expelled by heat, a process carried on usually in a limekiln. It is also driven from limestone by the action of sulphuric acid, with the formation of gypsum (a hydrous calcium sulphate), or anhydrite (an anhydrous calcium sulphate). These processes are often carried on in volcanoes, and hence carbonic acid gas is common in some volcanic regions. The Grotto del Cane (Dog Cave) at the Solfatara near Naples, is a small cavern
filled to the level of the entrance with this gas. It is a common amusement for the traveler to witness its effect upon a dog kept for that purpose. He is held in the gas awhile and is then thrown out apparently lifeless; in a few minutes he recovers himself, picks up his reward, a bit of meat, and runs off as lively as ever. If continued in the carbonic acid gas a short time longer, life would have been extinct.

Carbonic acid, under ligh pressure, becomes a liquid, and, with pressure and cold, a white snow-like solid. In the liquid state it is often found in microscopic globules in the interior of crystallized quartz, topaz, and some other minerals ; and when this is true, calcite (calcium carbonate) is often present in the same or an adjoining rock.

Besides the calcium carbonate in nature, there are also carbonates of ammonium, sodium, barium, strontium, magnesium, iron, manganese, zinc, copper, lead, nickel, cobalt, bismuth, uranium, cerium, and lanthanum.

## II. MINERALS CONSISTING OF THE BASIC ELEMENTS WITH OR WITHOUT ACIDICTHE SILICATES EXCLUDED.

## I. GOLD.

Gold occurs mostly native, being either pure, or alloyed with silver and other metals. It is occasionally found mineralized by tellurium, naking part of the valuable minerals Sylranite, Nagyagite and Petzite. It occurs often disseminated through pyrite and galenite in auriferous regions, rendering these minerals valuable sources of gold.

## Native Gold.

Isometric. In octahedrons, dodecahedrons; without clearage. Also in arborescent forms, consisting of strings of crystals, filiform, reticulated, in grains, thin laminæ and masses.

Color various shades of gold-yellow, becoming pale from alloy with silver; occasionally nearly silver-white from the silver present. Eminently ductile and malleable. H. = $2 \cdot 5-3$. G. $=12-20$, varying according to the metals alloyed with the gold. Fuses at $2,010^{\circ} \mathrm{F} \cdot\left(1,102^{\circ} \mathrm{C}\right.$.)

For the manufacture of the best pencils the granular graphite was thought necessary, and hence the former great value of the Borrowdale mine, where the texture was peculiarly fine and firm. But now the graphite is ground up, and then compressed under heavy pressure, and thus the fine texture and firmness required may be obtained with any pure graphite. At Sturbridge, Mass., it is rather coarsely granular and foliated, and has been extensively worked. The mines of Ticonderoga and Fishkill Landing, N. Y. ; of Brandon, Vt. ; and of Wake, North Carolina, are also worked ; and that of Ashford, Ct., formerly afforded a large amount of graphite, though now the works are suspended.

Graphite is extensively employed for diminishing the friction of machinery; also for the manufacture of crucibles and furnaces ; and as a wash for giving a gloss to iron stoves and railings. For crucibles it is mixed with half its weight of clay.

## Carbonic Acid.

Carbonic acid-carbon dioxide of existing chemistry-is the gas that gives briskness to the Saratoga and many other mineral waters, and to artificial soda water. Its taste is slightly pungent. It extinguishes combustion and destroys life.

Composition. $\mathrm{CO}_{4}=0 \mathrm{xygen} 72 \cdot 35$, carbon $27 \cdot 65=100$.
This gas is contained in the atmosphere, constituting about 4 parts, by volume, in 10,000 parts ; and it is present in minute quantities in the waters of the ocean and land. It is given out by animals in respiration, and is one of the results of animal and vegetable decomposition ; and from this source the waters derive much of their carbonic acid. This gas is the choke-damp of mines, where it is often the occasion of the destruction of life. It is often present also in wells.

Carbon dioxide (or carbonic acid) is given out by limestone (or calciam carbonate) when it is heated; and quicklime is limestone from which $\mathrm{CO}_{2}$ has been expelled by heat, a process carried on usually in a limekiln. It is also driven from limestone by the action of sulphuric acid, with the formation of gypsum (a hydrons calcium sulphate), or anhydrite (an anhydrous calcium sulphate). These processes are often carried on in volcanoes, and hence carbonic acid gas is common in some volcanic regions. The Grotto del Cane (Dog Cave) at the Solfatara near Naples, is a small cavern
filled to the level of the entrance with this gas. It is a common amusement for the traveler to witness its effect upon a dog kept for that purpose. He is held in the gas awhile and is then thrown out apparently lifeless; in a few minutes he recovers himself, picks up his reward, a bit of meat, and runs off as lively as ever. If continued in the carbonic acid gas a short time longer, life would have been extinct.

Carbonic acid, under high pressure becomes a liquid, and, with pressure and cold, a white snow-like solid. In the liquid state it is often found in microscopic globules in the interior of crystallized quartz, topaz, and some other minerals ; and when this is true, calcite (calcium carbonate) is often present in the same or an adjoining rock.

Besides the calcium carlonate in nature, there are also carbonates of ammonium, sodium, barium, strontium, margnesium, iron, manganese, zinc, copper, lead, nickel, cobalt, bismuth, uranium, cerium, and lanthanum.

## II. MINERALS CONSISTING OF THE BASIC ELEMENTS WITH OR WITHOUT ACIDICTHE SILICATES EXCLUDED.

I. GOLD.

Gold occurs mostly native, being either pure, or alloyed with silver and other metals. It is occasionally found mineralized by tellurium, making part of the valuable minerals Sylvanite, Nagyagite and Petzite. It occurs often disseminated through pyrite and galenite in auriferous regions, rendering these minerals valuable sources of gold.

## Native Gold.

Isometric. In octahedrons, dodecahedrons; without cleavage. Also in arborescent forms, consisting of strings of crystals, filiform, reticulated, in grains, thin laminæ and masses.

Color various shades of gold-yellow, becoming pale from alloy with silver; occasionally nearly silver-white from the silver present. Eminently ductile and malleable. H. = $2: 5-3$. G. $=12-20$, varying according to the metals alloyed with the gold. Fuses at $2,016^{\circ} \mathrm{F} .\left(1,102^{\circ} \mathrm{C}\right.$. $)$
reduce the material to loose earth and prepare it for further washing by the same water in sluices arranged for the purpose.

The minerals most common in gold regions are platinum, iridosmine, magnetite, pyrite, galenite, ilmenite, chalcopyrite, blende, tetradymite, zircon, rutile, barite ; also in some cases wolfram, scheelite, brookite, monazite and diamond. Platinum and iridosmine accompany the gold of the Urals, Brazil and California ; and diamonds are found in the gold region of Brazil, and occasionally in the Urals and United States.

Gold is widely distributed over the globe. In America, it occurs in Brazil (where formerly a greater part of that used was obtained) along the chain of mountains which runs nearly parallel with the coast, especially near Villa Rica, and in the province of Minas Geraes ; in New Granada, at Antioquia, Choco and Giron; in Chili ; sparingly in Peru and Mexico; in Arizona; in the Coast Range, and, much more abundantly, in the Sierra Nevada, California; in Oregon, British Columbia and Alaska; in New Mexico, Colorado, and Wyoming, and other parts of the Rocky Mountain region ; in the Appalachians from Virginia to Georgia, a region that formerly produced annually nearly a million of dollars ; very sparingly in Vermont, New Hampshire, and other New England States; in Nova Scotia ; in Beauce County, Canada; also, north of Lake Superior ; and in the gravel of Illinois and Indiana.

In Europe, it occurs sparingly in Cornwall and Deron, England ; North Wales, Scotland, and Ireland, formerly in the County of Wicklow, where a nugget of 22 ounces was found ; and in France, very sparingly in the Department of Isere ; in the sands of the Rhine, the Reuss, and the Aar; in Tyrol and Salzburg; on the southern slope of the Pennine Alps, from the Simplon and Monte Rosa to the Valley of Aosta, Northern Piedmont, where nearly 6,000 ounces were obtained in 1867 ; more abundantly in Hungary, at Königsberg, Schemnitz and Felsobanya, and in Transylvania, at Kapnik, Vöröspatak and Offenbanya ; in Spain, formerly worked in Asturias; in Sweden, at Edelfors.

In the Urals are valuable mines at Beresof, and other places on the eastern or Asiatic flank of this range, and the comparatively level portions of Siberia; also in the Altai Mountains. Also in the Cailas Mountains in Little Thibet ;
sparingly in the rivers of Syria and other parts of Asia Minor ; in Ceylon, China, Japan, Formosa, Java, Sumatra, Western Borneo, the Philippines, and New Guinea.

In Africa, at Kordofan, between Darfour and Abyssinia; also south of Sahara, in the western part of Africa, from the Senegal to Cape Palmas ; also along the coast opposite Madagascar, between the 22d and 35th degrees south latitude, in the Transvaal Republic. Other regions are Tasmania, New Zealand, and New Caledonia.

General Remarks.-The most productive gold regions at the present time are those of Australia and California.

In Australia the richest mines are those of Victoria and New South Wales. Victoria yielded, in 1856( $3,000,000$ ounces, and in $1875,1,195,-$ 250 ; Australia, in $18 \% 5,227,000$ ounces. The Australian gold was first made known to the world in 1851. The localities dispovered wero on Summer Hill Creck and the Lewis Pond River (ncar lat. $33^{\circ}$ N., long. $149^{\prime \prime}-150^{\prime} \mathrm{E}$ ), streams which run from the northern flank of the Coriobolas down to the river Macquarie, a river flowing westward and northward ; it was soon afterward found on the Taron River, which rises in the Blue Mountaius; and finally a region of country 1,000 miles in length, north and south, was proved to be auriferous; the country is a region of metamorphic rocks, granite and slates, and in many parts abounds in quartz veins. Queensland and South Australia, and also Tasmania and New Zealand, afford some gold.

The first discovery of gold in California was made early in the spring of 1845, on the American Fork, a tributary to the Sacramento, near the mouth of which Sutter's establishment was situated. Soon Feather River, another afluent, 18 or 20 miles north, was also proved to abound in gold about its upper portions; and it was not long after before each stream in succession, north and south, along the western slope of the Sierra Nevada was found to flow over auriferous sands. The gold as now developed extends along that chain, through the whole length of the great north and south valley which holds the rivers and plains of the Sacramento and San Joaquin. It continues south nearly to the Tejon pass, in latitude $35^{\prime}$, and north beyond the Shasta Mountains to the Umpqua, and less productively into Oregon and Washington Territories, and in British Columbia. Gold also oceurs in some places in the coast rango of mountains. Even the very site of San Francisco has been found to contain traces. North of Shasta Mountain there are important mines on the lilamath and the Umpqua, and some of the lest on the sea-shore between Gold Bluff, in 41 ' 30 ' south of the Klamath ( 30 miles south of Crescent City) to the Umpqua. What once was Rogue River is now called Gold River.

In Colorado, gold mines occur in Gilpin County, and much less productively in Clear Creck, Park, Boulder, Lake, Summit, and Southern counties; and the yield in 1874 amounted to $\$ 2,102,487$, of which $\$ 1,525,447$ were from Gilpin County.

Nevada produced from the Comstock lode (see p. 123), in 1875, gold to the amount of about $\$ 11,740,000$, and the rest of Nevada, $\$ 2,256,000$,
making in all nearly $\$ 14,000,000$; and in 1876 , the Comstock lode yielded $\$ 18,000,000$, and the rest of Nevada about $\$ 1,338,000$.

The yield of the United States in gold in the years 1870 to 18\%6, is stated as follows in a note dated February 5, 1877, by J. J. Valentine, in Jones's "Report of the Silver Commission (1877)":

| $18 \% 0$ | \$33,750,000 |
| :---: | :---: |
| 1871 | 84,398,000 |
| 1872 | 38,109,395 |
| 1873 | 39,206,558 |
| 1874 | $38,446,488$ |
| 1875 | 39,968,194 |
|  | 42,886,935 |

The amount, in 1874, from California is stated at $\$ 17,620,000$; from Oregon, $\$ 509.000$; Washington, $\$ 155,500$; ldaho, $\$ 1,328,430$; Montana, $\$ 2,850,000$; Utah, $\$ 92,000$; Arizona, $\$ 25,700$; Colorado, $\$ 2,-$ 102,487 ; Mexico, \$44,655 ; British Columhia, \$1,636,200.

According to the Report of A. del Mar, in the "Report of the Silver Commission of 18i7," the yield of gold from all America from 1492 to the year 1800, was $\$ 1,872,300,000$. From 1800 to 1847 inchasive, 48 years, the yield from America, Europo, and Africa is stated at $\$ 429,200,000$; and from 1843 to 1876 inclusive, 29 years, $\$ 3,381,500$,000 . The largest annual amount was produced in the year 1856 , in which the yield was $\$ 14 \pi, 600,000$; and next to this, in 1859 , with $\$ 144,900,000$; as shown in the annesed table, giving the amounts in millions of dollars:

| 1843....... ${ }^{\text {a }}$ | 1859. . . . 144 ¢ | 1898. . . . $109 \cdot 7$ |
| :---: | :---: | :---: |
| 1849...... . 87.0 | 1859 . . . . . 1149 | 1869. . . . . $106{ }^{\circ}$ |
| 1850...... . 93.2 | 1860 . . . . $110 \cdot 3$ | 1870 . . . $1019 \cdot 9$ |
| 1851 . . . . . . $120 \cdot 0$ | 1811. . . . . $113 \cdot 9$ | 1871... . 1070 |
| 1853 . . . . . 193.7 | 1863.....1078 | 1872..... 996 |
| 1853. . . . . . 1555 | 1863. . . . $107 \cdot 0$ | 1873. . . . 97\% |
| 1854....... $19 i^{\circ} 0$ | 186t..... $113 \cdot 0$ | 1871.... 90.8 |
| 1855 . . . . . 13.15 | 189.9. . . . $130 \cdot 7$ | 1875. . . . 975 |
| 18566...... . 1476 | 1806. . . . 129.20 | 1876.... 90.0 |
| 1857...... . $133 \cdot 3$ | 18:7. . . . . $114 \cdot 0$ |  |

The total amount for these years is $\$ 3,381,500,000$ The following table is taken from a Report to the British Houst of Commons in 1876 -the amount for the United States only being corrected:


Masses of gold of considerable size have been found in North Car. lina. The largest was discovered in Cabarrus County; it weighed 28 pounds avoirdupois ("steel-yard weight," equals 37 pounds troy). and was 8 or 9 inches long, by 4 or 5 broad, and about an inch thick. In Paraguay, pieces from 1 to 50 pounds weight were taken from a mass of rock which fell from one of the highest mountains.

The largest masses of gold yet discovered have been found in auriferous gravel. The "Blanch Barkley Nugget," found in South Australia, woighed 140 pounds, and only six ounces of it were gangue ; and one still larger, the "Welcome Nugget"" from Victoria, weighed 2,195 ounces, or nearly 183 pounds, and yielded $£ \&, 376$ 10s. $6 d$, sterling of gold. Two others from Victoria weighed 1,621, and 1,105 ounces. In Russia, a mass was found in 1842, near Miask, weighing 96 pounds troy ; another of 27 pounds, and several of 16 pounds have been found in the Urals. The largest mass yet reported from California weighed 20 pounds. A remarkably beantiful mass, consisting of a congeries of crystals, weighing 201 ounces (value $\$ 4,000$ ), was found in 1865 , seven miles from Georgetown, in El Dorado County.

The crigin of gold veins, or rather of the gold in the veins, is little understood. The rocks, as has been stated, are metamoryhic slates that have been crystallized by heat; and they are the lyydromica. chloritic, and argillaceous, that have been but imperfectly crystallized, rather than the mica schist and gneiss, which are well crystallized; and the veins of quartz which contain the gold, occupy tissures through the slates, and ojening; among the layers, which must have been made when the metamorphic changes or erystallization took place. It was a period, for each gold region, of long-continued heat (occupying, probably, a prolonged age), and also of vast upliftings and disturhances of the beds; for the beds are tilted at various angles, and the veins show where were the fractures of the layers, or the separations and gapings of the tortured strata. The heat appears not to have been of the intensity required for the better crystallization of the more perfectly crystalline schists. The quartz veins could not have been filled from below, by injection; they must have been filled either laterally, or from above. In all such conditions of upturning and metamorphism, the moisture present would have become intensely heated, and hence have had great dissolving and decomposing power; it would have taken up silica with alkalins from the rocks (as happens in all Geyser regions), along with whatever other mineral substances were capahle of solution or removal ; and the vapor, thus laden, would have filled all open spaces, there to make depositions of the silica and other ingredients it contained. These mineral ingredients would have been derived either from the rock adjoining the veins or opened spaces, or from depths below through ascending vapors. By one or both of these means, the quartz must have received its gold, pyrite, and ores of lead, copper and other materials-all having been carried into the open cavities at the same time with the silica or quartz. The pyrite of the vein is usually aurifcrous, showing that it was crystallized under the same circumstances that atiended the depositing of the grold in strings, crystals, and grains; and the same is often true of the galena.
is a bronze-yellow gold telluride. $\mathrm{Au} \mathrm{Te}_{4}=\mathrm{Tellarium}$
55.5, gold $44 \cdot 5=100$, with a little silver, occurring massive at the Stanislaus Mine, California, and the Red Cloud Mine, Colorado, and also the Keystone and Mountain Lion mines, in the Magnolia District.

Krennerite is another gold telluride.
Sylvanite, called also Graphic tillurium, is a telluride of gold and silver, also containing sometimes antimony and more or less lead (see p. 118).

Nagyagite is a telluride of lead containing 9 to 13 per cent. of gold (see p. 149).

Petzitc is a telluride of silver, allied to Hessite (p. 118), containing gold ; a specimen from Golden Rule Mine, Colorado, contained 25.60 per cent, accurding to Genth.

## II. SILVER.

Silver occurs native, and alloyed, or combined with gold ; also combined with sulphur, selenium, tellurium, arsenic, antimony, lismuth, chlorine, bromine, or iodine; but never as an oxide, carbonate, sulphate, or phosphate.

## Native Silver.

Isometric. In octahedrons and other forms. No cloavage apparent. Occurs often in filiform and arborescent shapes, the threads having a crystalline character ; also in laminæ, and massive.
Color and streak silver-white and shining. Often black externally from tarnish. Sectile. Malleable. H. $=2 \cdot 5-3$. G. $=10 \cdot 1-11 \cdot 1$.

Composition. Native silver is usually an alloy of silver and copper, the latter ingredient often amounting to 10 per cent. It is also alloyed with gold, as mentioned under that metal. A bismuth silver from Copiapo, S. A., contained 16 per cent. of bismuth.
B.13. fuses easily to a silver-white globule. Dissolves in nitric acid, from which it is precipitated as white chloride on adding hydrochloric acid. A clean plate of copper immersed in the nitric solution becomes coated with silver.

Diff. Distinguished by being malleable; from bismuth and other white native metals by affording no fumes before the blowpipe; by affording a precipitate with hydrochloric acid which becomes black on exposure.

Obs. Native silver occurs in masses and string-like arborescences, penctrating the gangue, or its minerals, in
varions silver mincs. It is also found mixed with native copper.
The mines of Norway, at Kongsberg, formerly afforded magnificent specimens of native silver, but they are now mostly under water. One specimen from this locality, at Copenhagen, weighs five hundred pounds; and two other masses have been found weighing 238 and 436 pounds. Other European localities are in Saxony, Bohemia, the Hartz, Hungary, Dauphiny. Peru and Mexico also afford native silver. A Mexican specimen from Batopilas, weighed when obtained 400 pounds ; and one from Southern Peru (mines of Huantajaya) weighed over 8 cwt. Arizona is reported to have produced one mass weighing $2, \% 00$ pounds. In the United States, in the Lake Superior region, the silver gencrally penetrates the copper in masses and strings, and is very nearly pure, notwithstinding the copper about it. Large masses occur at the Idaho Silver Mine, callel the Poor Man's Lode; and in strings it is occasionally found in the mines of N vada, California, and Colorado.
Much of the galena of the world contains a very small pes centage of silver ; that of Mouroc, Comn., yields nearly 3 per cent.

Native silver has also been observed near the Sing Sing state prison ; at the Bridgewater copper mines, N. J. ; and in handsome specimens at King's Mine, Davidson County, North Carolina.
Native Amalgam is a compound of silver and mercury. The compounds $\mathrm{Ag} \mathrm{Hg}=$ Silver $35 \cdot 1$, mercury $64 \cdot 9$, or $\mathrm{Ag}_{2} \mathrm{H}_{3}=$ Silver 26.5 , mercury $73 \%$, are included. Another from Chili having the formula $\mathrm{Ag}_{12} \mathrm{Hg}$ and containing $86^{\circ} 6$ per cent. of silver has been called $A r$ querite; and still another $\mathrm{Ag}_{1 \mathrm{t}} \mathrm{II}$, Longsbcrgite.

Argentite.-Silver Glance. Sulphuret of Silver.
Isometric. In dodecahedrons more or less modified. Cleavage sometimes apparent parallel to the faces of the dodecahedron. Also reticulated and massive.

Lustre metallic. Color and streak blackish lead-gray; streak shining. Very sectile. II. $=2-2 \cdot \mathrm{~J} . \quad$ G. $=7 \cdot 19-$ 74.

Composition. When pure, $\mathrm{Ag}_{2} \mathrm{~S}=$ Sulphur $12 \cdot 9$, silver $8 \% \cdot 1$. B. B. on charcoal in 0.F. it intumesces, gives off the odor of sulphur, and finally affords a globule of silver.

Diff. Resembles some ores of copper and lead, and other
ores of silver, but is distinguished by being easily cut, like lead, with a knife; and also by affording a globule of silver on charcoal, by heat alone. Its specific gravity is much higher than that of any copper ores.

Obs. This important ore of silver occurs in Europe principally at Annaberg, Joachimstahl, and other mines of the Erzgebirge ; at Schemnitz, and Kremnitz, in Hungary, and at Freiberg in Saxony. It is a common ore at the Mexican silver mines, and also in the mines of South America. It occurs in Arizona, with chalcocite, at the Heintzelman Mine, and in Nevada.

A mass of "sulphuret of silver" is stated by Troost to have been found in Sparta, Tennessec.

Acanthite is a trimetric sulphide of silver, $\mathrm{Ag}_{2} \mathrm{~S}$, from Joachimstahl ; and Daleminzite, another, from near Freiberg.

Stromeyerite. A steel-gray sulphide of silver and copper, $\mathrm{Ag}_{5} \mathrm{~S}$ $+\mathrm{Ca}_{2} \mathrm{~S}=$ Sulphur $15 \cdot \%$, silver $53 \cdot 1$, copper $31 \cdot 2=100$. $\mathrm{G} .=6 \%{ }^{2} 0$. B.B. it fuses and gives in the open tube an odor of sulphur; but a silver globule is not obtained except by cupellation with lead. From Peru, Silesia, Chili, Siberia, and Arizona.

Sternbergite. A sulphide of silver and iron containing 33 per sent. of silver. It is a highly foliated ore resembling grajhite, and like it leaving a tracing on paper ; the thin laminx are llexible; color pinchbeck brown ; streak black. From Joachimstahl and Johanngeorgenstadt.
Naumannite. A selenide of silver and lead in iron-black cubes and massive ; G. $=8$; contains 73 per cent. of silver. From the Hartz.

Hessite. A telluride of silver, $\mathrm{Ag}_{3} \mathrm{Te}=\mathrm{Tellurium} 37 \cdot 2$, silver $62 \cdot 8=$ 100. Color between lead-gray and steel-gray. Sectile. G. $=8 \cdot 3-8 \cdot 6$. B.B. in the open tube, faint sublimate of tellurous acid; on charcoal with soda a silver globule. From the Altai; at Nagyag and Retzbanya; Coquimbo, Chili ; Calaveras Co., Cal.; Red Cloud Mine, Colorado ; Kearsarge Mine, Dry Canyon, Utah.

Petzite is a hessite with the silver replaced in part by gold. $G .=$ $8 \cdot 7-9.4$. Between steel-gray and iron-black. Variety from Golden Rule Mine, afforded Genth Tellurium 32.68, silver $41 \cdot 86$, guld $25 \cdot 60=$ 10014 . Occurs at the same localities with hessite.

Tapalpite is a telluride of bismuth and silver from Mexico.
Sylvanite or Graphic Tellurium. A telluride of gold and silver ( $\mathrm{Ag}, \mathrm{Au}$ ) $\mathrm{Te}_{3}=($ if $\mathrm{Ag}: \mathrm{Au}=1: 1$ ) Tellurium $55 \cdot 8$, gold 28.5 , silver $15 \%$ $=100$. Color and streak steel-gray to silver-white, and sometimes nearly brass-yellow. H. $=1 \cdot 5-2 . \quad \mathbf{G}=\tilde{7} \cdot 99-8.33$. Called graphic because of a resemblance in the arrangement of the crystals to writing characters. From Transylvania; Calaveras Co., California; Red Cloud and Grand View Mines, Colorado.

Eucairite. A selenide of silver and copper, containing 42-45 per cent. of silver ; color between silver-white and lead-gray ; easily cut by the knife. From Sweden and Chili.


#### Abstract

Dyserasite, or Antimonial Silver, eonsists simply of silver and antimony ( 78 parts to $22=\mathrm{Ag}$, Sb ), and has nearly a tin-white color. G. $=9 \cdot 4-9 \cdot 8$. B.B. fumes of antimony pass off, leaving finally a globule of silver. From Wolfach, Wittichen, Andreasberg; also Allemont in Dauphiny ; and Bolivia, S. A.


## Pyrargyrite.-Ruby Silver. Dark Red Silver Ore.

Rhombohedral. $\quad R \wedge R=108^{\circ} 42 ; R \wedge i-2=129^{\circ} 39^{\prime}$. Cleavage parallel to $R$ imperfect. Also massive. Black to dark cochineal-red, with the streak cochi-neal-red and lustre splendent metallic-adamantine. H. $=2-2 \cdot 5$, G. $=5 \cdot{ }_{6}^{\prime}-5 \cdot 9$.

Composition. $\mathrm{Ag}_{3} \mathrm{~S}_{3} \mathrm{Sb}\left(=3 \quad \mathrm{Ar}_{2} \mathrm{~S}+\mathrm{Sb}_{2}\right.$ $\left.S_{3}\right)=$ Sulphur $17 \%$, antimony $22 \cdot \%$, silver $59 \cdot 8=100$.
B.B. fuses very casily : on charcoal a
 white deposit of antimony oxide is deposited, and with soda a globule of silver is obtained. In an open tube gives off sulphurous fumes that redden litmus paper.

Diff. Its red streak, and its reactions for antimony and silver, are distinctive.

Obs. Oceurs at Andreasberg ; also in Saxony, Hungary, Cornwall, Mexico, Chili ; in Nevada at Washoe ; abundant about Austin, Reese River ; at Poor Man’s Lode, Idaho.

Proustite, or Light Red Silver Ore, is a related ore containing arsenic in place of much or all of the antimony. Composition, $\Lambda g_{3} S_{3} A s=$ Sulphur $10 \cdot 4$, arsenic $15 \cdot 1$, silver $65 \cdot 5=100 . \quad$ G. $=5 \cdot 4-5 \cdot 56$.
B.13. gives a garlic odor.

Occurs with pyrargyrite at the above-mentioned localities.
Stephanite.-Brittle Silver Ore. Black Silver.
Trimetric. $I_{\wedge} I=115^{\circ} 39^{\prime}$. No perfect clearage. Often in compound crystals. Also massive. Streak and color iron-black. $\quad \mathrm{II}=2-2 \cdot 5 . \quad \mathrm{G} .=6 \cdot 2 \%$.

Composition. $\mathrm{Ag}_{5} \mathrm{~S}_{4} \mathrm{Sb}\left(=5 \mathrm{Hg}_{9} \mathrm{~S}+\mathrm{Sb}_{4} \mathrm{~S}_{3}\right)=$ Sulphur $16 \cdot 2$, antimony $15 \cdot 3$, silver $68 \cdot 5$. 13.13. it gives an odor of sulphur and also fumes of antimony, and yields a dark metallic globule, from which silver may be obtained by the addition of soda. Soluble in dilute nitric acid, and the solution indicates the presence of silver by silvering a plate of copper.

Ols. It occurs with other silver ores at Freiberg, Schneeberg, and Johanngeorgenstadt, in Saxony; alse in Bohemia, and Hungary. It is an abundant ore in Chili, Peru, and Mexico, and also in Nevada, and at the Comstock Lode, and at Ophir, and Mexican mines, in the Reese River and Humboldt, and other regions; in Colorado and Idaho. It is sometimes called black silver.
Polybasite is near stephanite in color, specific gravity, and composition, but contains some arsenic and copper, with 64 to $22 \cdots$ per cent. of silver. The crystals are trimetric, and usually in tabular hexagonal prisms, without distinct cleavage. G. $=6,214$. From Freiberg, Przibram ; Mexico and Chili; the Reese mines in Nevada, und ldaho.

Miargyrite is an antimonial silver sulphide, containing but 36.5 per cent. of silver, and having a dark cherry-red streak, though iron-black in color. B.B. on charconl gives off fumes of antimony and an odor of sulphur; and in the oxidating flame, a globule is left which finally yields a button of pure silver.

Brongniardite occurs in regular octahedrons and massive, grayishblack in color, and contains about 25 per cent. of silver, with lead, antimony, and sulphur. G. $=5 \cdot 95$. From Mexico.
Polyargyrite also is isometric, having cubic cleavage, and is from Wolfach in Baden. It is near polybasite in composition $=1 \geqslant \mathrm{Ag}_{2} \mathrm{~S}+$ $\mathrm{Sb}_{2} \mathrm{~S}_{5}$.
Freiestebenite is a monoclinic antimonial silver-and-lead sulphide, of a light steel-gray color, with $G .=6-6 \cdot 4$. Contains 22 to 24 per cent. of silver. From Saxony, Transylvania, and Spain.

Pyrostilpnite is another monoclinic silver ore; its delicate crystals are grouped like stilbite and have a fire-red color. Contains 62.3 per cent. of silver. From Freiberg, Andreasberg, and Przibram.

## Cerargyrite.-Horn Silver. Silver Chloride.

Isometric. In cubes, with no distinct cleavage. Nlso massive, and rarely columnar ; often incrusting. Color gray, passing into green and blue ; looks somewhat like horn or wax, and cuts like it. Lustro resinous, passing into adamantine. Streak shining. Translucent to nearly opaque.

Composition. $\mathrm{AgCl}=$ Chlorine $24 \cdot 7$, silver $75 \cdot 3$. Fuses in the flame of a candle, and emits acrid fumes. B.B. affords silver easily on charcoal. The surface of a plate of iron rubbed with it is silvered.

Obs. A very common ore and extensively worked in the mines of South America and Mexico, where it occurs with native silver ; and also abundant in Nevada about Austin, Lander Co. ; in Idaho at Poor Man's Lode ; occurs also in Comstock Lode ; and in Arizona; also at the mines of Saxony, Siberia, Norway, the Hartz, and Cormwall.

Bromyrite or Bromic Silver. Silver united with bromine. $\mathrm{Ag} \mathrm{Br}=$ Bromine $4: 6$, silver $57 \cdot 4=100$. Occurs with the preceding in Mexico and Chili.

Embolite. A chlorobromide of silver, resembling the chloride or horn silver. Color asparagus to olive green. Contains 51 of chloride of silver, to 49 of bromide. This ore is not less common in Chili than the chloride. It has also been found in Chihuahua, Mexico.
Iodyrite. A silver iodide, $\mathrm{Ag} \mathrm{I}=$ Iodine $54 \cdot 0$, silver $46.0=100$. It has a bright yellow color. From Spain, Chili, Mexico, and the Cerro Colorado Mine in Arizona.

Tocornalitc. A silver-and-mercury iodide from Chili.
General Rcmarks.-The chief sources of the silver of commerce are (1) Native silver ; ( 2 ) the sulphide, Argentite (or vitrenus silver), common in Mexico, and also in the Humboldt, Recse River mining districts; four species among the sulpharsenites and sulphantimonites, viz., (3) Proustite or the light red or ruby silver ore, and (4) Pyrar. gyrite, or dark red silver ore, both common in Chilian, Peruvian, and Mexican mines ; (5) Frcieslcbenite ; (6) Argcntifcrous tctrahedrite, which contains sometimes 10 to 30 per cent. of silver, abundant at some Humboldt County, Nevada, mines, at Colorado silver mines, and at various Chilian, Bolivian and Mexican mines, as well as in some silver mines of Europe ; (7) Stephanite or brittle silver ore, common in Nevada, Colorado, and at the Washoe mines, Western Utah ; ( 8 ) the chloride, called horn-silver or Cerargyrite, common in Chili, Mexico, Idaho; (9) the bromidn and chlorobromide, Bromyrite and Embolite, common in Chili and Mexico, especially the latter, along with the rarer iodide ; (10) Argcntiferous Gatenite, the lead ore, galenite, cven when containing but 5 ounces of silver to the ton, being profitably worked for its silver. The other ores of silver mentioned beyond are seldom of great abundance. The most important of them are silver amalgam or Arquerite, common especially in Chili, and Polybasite.
Silver ores occur in rocks of various ages, in gnciss and allied rocks, in porphyry, trap, sandstone, limestone, and shales; and the sandstone and shales may be as recent as the 'lertiary. The veins often intersect trachytic, porphyry, and other eruptive rocks, or the sedimentary formations in the vicinity of such rocks, and have owed their existence in many cases to the heat, fracturing, and vapors from below, attending the rruptions.
Silver ores are associated often with ores of lead, zinc, copper, cobalt, and antimony, and the usual gangue is calcite or quarta, with frequently thuor sjar, pearl spar, or heavy spar.

The silver of South America is derived principally from the horn silvers, stephanite, ruly silver, vitroous silver ore, and native silver. Those of Mexico are of nearly the same character. Besides, there aro carthy ores called colorados, and in Peru pacos, which are mostly earthy oxide of iron, with a little disseminated silver; they are found near the surface where the rock has undergone partial decomposition. The sulphides of lead, iron, and copper of the mining regions, generally contain silver, and are also worked.
In South America the Chilian mines are on the western slope of the Cordilleras, and are connected mostly with stratificd deposits, of a shaly, sandstone, or conglomerate character, and their intersections
with porphyries. The chlorides and native amalgams are found in regions more toward the coast, while the sulphides and antimonial ores abound nearer the Cordilleras. The richest mines are not far distant from Copiapo, in the mountains north of the valley of Huasco. The mines of Mt. Chanarcillo, about 16 lengues south of Copiapo, abound in horu silver, and begin to yicld arsenio-sulphides at a depth of about 500 fect. The mines of Punta Brava, which are nearer the Cordilleras, afford the arsenical and antimonial ores.

In Peru, the principal mines are in the districts of Pasco, Chota, and Huantaya. Those of Pasco are 13,700 fet above the sea, while those of IIuantaya are in a low desert plain, near the port of Yquique, in the southern part of Peru. The ores afforded aro the same as in Chili. The mines of Ifuantaya are noted for the large masses of native silver they have afforded. Silver is obtained in Peru, also, in the districts of Caxamarca, Pataz, Huamanchuco, and Hualgayoc.
The Potosi mines in Bolivia, occur in a mountain of argillaceons shale, whose summit is covered by a bed of argillaceous perphyry. The ore is the ruby silver, and argentite with native silver. The district of Caracoles, between Chili aud Bolivia, yields much silver.
In Europe the principal mines are those of Spain, the province of Guadalajara, where the ore is chiefly freieslebenite; of Kongsberg in Norway; of Saxony, chicfly at Freiberg ; the Hartz; in Austria, Mungary, Trunsylvania, and the Banat ; and Russia. The mines of Kongsberg occurin gneiss and hornblende slate, in a gangue of calc spar. They were especially rich in native silver.
The mines of Saxony occur mostly in gneiss, in the vicinity of Froiberg, Ehrenfriedensdorf, Johanngeorgenstadt, Annaberg, and Schnceberg.

The ores of the Hartz are mostly argentiferous copper pyrites and galena, yet the ruby silver, argentite, stephanite, occur, especially at Andreaskreatz, and the mines of that vicinity. The rock intersected by the deposits is mostly an argillaceous shale. Calcite is the usual gangue, though it is sometimes quartz.
In the Tyrol, Austria, argentite, argentiferous tetrahedrite, and mispickel occur in a gangue of quartz, in argillaceous schist. The Hungarian mines at Schemnitz and Kremnitz, occur in syenyte and hornblende porphyry, in a gangue of quartz, often with calcite or barito (heavy spar), and sometimes fluorite. The ores are argentite. tetrahedrite, galena, blende, pyritous copper and iron; and the galeua and copper ores are argentiferous. France produces some wilver from argentifcrous galena at Huelgoet in Drittany, and the mines of Pontgiband, Pay-de-Dome.
The Russian mines are in Kolyvan in tho Altai, and Nertchinsk in the Daouria Mountains, Siberia (east of Lake Baikal). The Daouria mines afford an argentiferous galena which is worked for its silver; it occurs in a crystalline limestone. The silver ores of the Altai occur in Silurian schists in the vicinity of porphyry, which contain also gold, copper, and lead ores.
The mines of Mexico are most abundant between $18^{\circ}$ and $24^{\circ}$ north latitude, on the back or sides of the Cordillcras, and especially the west side ; and the principal are those of the districts of Guanaxuato. Zacatecas, Fresnillo, Sombrerete, Catorce, Oaxaca, Pachuca, Real del Monte, Batopilas, and Tasco. The veins traverse very different rocks
in theso regions. The vein of Guanaxuato, the most productive in Mexico, intersects argillaceous and chloritic shale, and porphyry; it affords one-forth of all the Mexican silver. The Valencian mine is the richest in Guanaxuato. The Pachuca, Real del Monte, and Moro districts, are near one another. Four great parallel veins tranverse these districts, through porphyry.
In the United States the chief silver mines are in California, Nevada, Colorado, Utah, Montana, and Idaho. The principal California mines are in its southeastern counties bordering on Nevada, namely: Alpine, Mono, and Inyo ; the total yield in 18i4, about $\$ 1,700,000$. Those of Nevada are the Washoe region, about Virginia City and the Comstock Lude; in Lander County, along Reese River Valley, etc., the chicf town of which is Austin; Ksmeralda County, southeast of Washoe; in Eureka County, next east of Lander ; in Lincoln County, the southeastern of the State ; Humboldt County to the north ; White Pine, Nye and Elko counties, east and southeast of Lander County. The rocks connected with the veins in Eastern California and Western Nevadu are cruptive rocks, related for the most part to andesyte (in part, named propylite) and trachyte, with some doleryte. The mines of Utah, are those of the Big and Little Cottonwood districts (which include the Emma Mine), the American Fork district, the Parley's Park district in the Wahsatch Range north of Big Cottonwood, and the East Tintic district, in which aro the Eureka Hill mines; those of Arizona, the Heintzelman, etc.; of Colorado, in the San Juan region; of Northern Michigan, at the copper mines; of Canala, at Prince's Mine, Spar Island, Lake Superior.
For the years previous to 1839 the whole yield of silver from United States mines is estimated at $\$ 1,000,000$. The following are the amounts for the succeeding years, as published in Jones's Senate Report (1877), those for the years 1871 to 1876, inclusive, being from estimates by J. J.Valentine.

| 1859. | \$100,000 | 1868 | ,000 |
| :---: | :---: | :---: | :---: |
| 1860. | 150,000 | 1869. | 13,000,000 |
| 1801. | 2,100,000 | 1870 | 17,3:0,000 |
| 1862. | 4,500,000 | 18.1 | 19, $\because 86,000$ |
| 18133 | 8,500,000 | 1872. | 19,924,429 |
| 1864. | 11,000,000 | 1873 | 27,483,302 |
| 18.5. | 11,250,000 | 1874. | 29,699,122 |
| 1866. | 10,000,000 | 1875. | 31,635,239 |
| 1867. | 13,550,000 | 1876 | 39,292,924 |

The Comstock Lode contributed to the silver of the world first in 1861. In 1875 it yielded $\$ 14,492,350$, and the rest of Nevada $\$ 6,717,636=$ $\$ 21,209,98 ; \%$ und in $18 \% 6$ these amounts were 20,5000 is and $7,46^{\circ}, 752$ $=\$ 28,03 ?, 8: 30$. The $87,462.752$ from the "rest of Nevada" in 18i6, were divided, as follows, between its principal mining regions: Lander County, Austin district, $\$ 1,187,500$; Esmeralda County, Columbus district, $\$ 1,624,789$; Elko County, Cornucopia district, $\$ 460,048$; Eureka County, $\$ 1,480,558$; Lincoln County, Pioche or Ely district, $\$ 790.095$; Nye County. Tyboe and Reveille districts, $\$ 1,450,000$.
The yield in 1876 of Utah was $\$ 3,351,5 \div 0$; of Colorado, $3,000,000$; of California, $1,800,000$; of Arizona, 500,000 ; of Montana, 800,000 ; of Idaho, 300,000 ; of New Mexico, 400,000 .

In the " Elements of Metallurgy," of J. Arthur Phillips, the yield for 1872 is given approximately, as follows:

|  | Lbs. Troy. |
| :---: | :---: |
| Great Britain. | 52,400 |
| Norway and Sweden. | 15,000 |
| Hungary, Transylvania, and the Banat... | 92,000 |
| Saxony . . . . . . . . . . . . . 80,000) |  |
| Haruz. . . . . . . . . . . . . . 27,500 | 178,000 |
| Test of Germany. . . . . . 60,500$)$ |  |
| Russia. | 50,000 |
| France | 16,500 |
| Italy. | 32,000 |
| Spain. | 100,000 |
| Peru. | 200,000 |
| Bolivia. | 450,000 |
| Chili. | 300,000 |
| Central America | 53,000 |
| Mexico | 1,000,000 |
| United States | 1,:50,000 |
| Total. | 3,788,900 |

Mr. Phillips states that the total for the year probably amounted to $4,100,000 \mathrm{lbs}$. troy, the value of which is $\$ 13,000,000$, or $\$(63,000,000$. In the above the amount from the United States is diminished to make it correspond with the preceding statement for 1872.

The following table gives, in dollars, the estimated value of the world's production of silver in recent years :

|  | Russia. | United States | Mexiconal south America | Other Countries. |
| :---: | :---: | :---: | :---: | :---: |
| 1855 | 600,000 |  | $30,000,000$ | $10,000,000=40,600,000$ |
| 1860 | 650,000 | 150,000 | 30,000,010 | $10,000,000=40,810,000$ |
| 1865 | 700,000 | 11,250,000 | 30,000,000 | $10,000,000=51,950,000$ |
| 1870 | 575,000 | 17,320,000 | 25,000,000 | $10,000,000=57,895,000$ |
| 1875 | 500,000 | 31,635,000 | 25,000,000 | $10,000,000=67,185,000$ |

The total for 1876 is estimated at 76 millions.
The world's production of silver for the period of twenty-six years, from 1802 to $187 \%$, is ostimated at $\$ 1,341,800,000$; for the preceding twenty-two years-from 1830 to 1851 , inclusive-at $\$ 600,400,000$; for the preceding thirty yoars-from 1800 to 1890 -at $\$ 790,100,000$.

## Native Platinum.

Isometric : but crystals seldom observed. Usually in flattened or angular grains or irregular masses. Cleavage none.

Color and streak pale or dark steel-gray. Lustre metallic,
shining. Ductile and malleable. H. $=4-4 \cdot 5 . \quad$ G. $=16-19$; $17 \cdot 108$, small grains; $17 \cdot 608$, a mass. Often slightly magnetic, and some masses will take up iron filings.

Composition. Platinum is usually combined with more or less of the rare metals iridium, rhodium, palladium, and osmium, besides copper and iron, which give it a darker color than belongs to the pare metal, and increase its hardness. A Russian specimen afforded, Platinum $88 \cdot 0$, iridium $5 \cdot 0$, osmium and iridium $1 \cdot 9$, rhodium $0 \cdot 9$, palladium $0 \cdot 3$, copper $0 \cdot \%$, iron $11 \cdot 0=98 \cdot \% 5$.

Platinum is soluble in heated aqua regia. It is one of the most infusible substances known, being wholly unaltered before the blowpipe. It is rery slightly magnetic, and this quality is increased by the iron it may contain.

Diff. Platinum is at once distinguished by its malleability and extreme infusibility.

Obs. Platinum was first detected in 1735 in grains in the alluvial deposits of Choco and Barbacoa in New Granada (now U. States of Colombia), within two miles of the northwest coast of South America, where it received the name platina, derived from the word plata, meaving silver. Although before known, an account by Clloa, a Spanish traveler in America in 1735, directed attention in Europe, in 1748 , to the metal. It is now obtained in Novita, and at Santa Rita, and Santa Lucia, Brazil. It has been afforded most abundantly by the Urals. It occurs also on Bornco ; in the sands of the Rhine: in those of the river Jocky, St. Domingo ; in traces in the United States, in North Carolina; at La François Beauce, Canada ; and with gold near Point, Orford, on the coast of Northern California (prohably derived, according to W. P. Blake, from serpentine rocks) ; in British Columbia.

The Ural localities of Nischne Tagilsk and Gorohlagodat have afforded much the larger part of the platinum of commerce. It occurs, as elsowhere, in alluvial beds; but tho courses of platiniferous alluvium have been traced to a great extent up Mount La Martiane, which consists of crystalline rocks, and is the origin of the detritus. One to three pounds are procured from 3, $\% 00$ pounds of sand.

Though commonly in small grains, masses of considerable size have occasionally been found. A mass weighing 1,088 grains was brought by Humboldt from South America and deposited in the Berlin Museum. Its specific gravity was
18.94. In the year 1822, a mass from Condoto was deposited in the Madrid Museum, measuring 2 inches and 4 lines in diameter, and weighing 11,641 grains. A more remarkable specimen was found in the year 1827 in the Urals, not far from the Demidoff mines, which weighed $11 \frac{1}{2}$ (more accurately, 11.57 ) pounds troy; and similar masses are now not uncommon. The largest yet discovered weighed 21 founds troy; it is in the Demidoff cabinet.
hussia affords annually about 35 cwt. of platinum, which is about five times the amount from Brazil, Borneo, Colomhia, and St. Domingo. Borneo affords about 500 pounds per year.

The North Carolina platinum was found with gold in Rutherford County. It was a single reniform granule, weighing 2.54 grains. Other instances are reported from the Southern gold region.

The infusibility of platinum and its resistance to the action of the air, and moisture, and most chemical agents, renders it of great value for the construction of chemical and philosophical apparatus. The large stills employed in the concentration of sulphuric acid are now made of platinum ; but such stills are gilt within, since platinum when unprotected is acted upon by the acid, and soon becomes porous. It is also used for crncibles and capsules in chemical analysis; for galvanic batteries; as foil, or worked into cups or forceps, for supporting objects before the blowpipe. It alloys readily when heated with iron, lead, and several of the metals, and is also attacked by caustic potash and phosphoric acid, in contact with carbon ; and consequently there should be caution when heating it not to expose it to these agents.

It is employed for coating copper and brass; also for painting porcelain and giving it a steel lustre, formerly highly prized. It admits of being drawn into wire of extreme tenuity.

Platinum was formally coined in Russia. The coins had the value of 11 and $2 \%$ rubles each.

This metal fuses readily before the "compound blowpipe ;" and Dr. Hare succeeded in 1837 in melting twentycight ounces into one mass. The metal was almost as malleable and as good for working as that obtained by the other process; it had a specific gravity of $19 \cdot 8$. He afterwards succeeded in obtaining from the ore masses which were 90
per cent. platinum, and as malleable as the metal in ordinary use, though somewhat more liable to tarnish, owing to some of its impurities. Deville and Debray have perfected this process, and have melted over 25 pounds of platinum in less than three-quarters of an hour. In the process the osmium present is oxidized and thus removed.

Platin-iridium. Grains of iridium have been obtained at Nischne Tagilsk, consisting of 76.8 iridium, and 19.64 platinum, with some palladium and copper. A similar platin-iridium has been obtained at Ava, in the East Indies. Another, from Brazil, contained 27.8 iridium, 55.5 platinum, and 6.9 of rhodium.

Iridosmine. A compound of iridium and osmium from the platinum mines of Russia, South America, the East Indies, and California. The crystals are pale steel-gray hexagonal prisms; usually in flat grains. $\mathrm{H}:=6 \%$. G. $=19 \cdot 5-21 \cdot 1$. Malleable with difficulty.

The composition varies. One variety, called Nerjansloite, contains iridium $46 \cdot 8$, osmium 493 , rhodium 32 , iron 0.7 . Another, Sisserskite, iridium $25 \cdot 1$, osmium $74 \cdot 9$, and iridium 20 , osmium 80 . But analysis affords also from 0.5 to 12.3 of rhodium, and 0.2 to 6.4 of the rarer metal ruthenium, with traces usually of platinum, copper and iron. The grains are distinguished by their superior hardne.ss from those of platinum, and also by the peculiar odor of osmium when heated with nitre. Iridosmine is common with the gold of Northern California, and injures its quality for jewelry. Occurs sparingly in the gold washings on the rivers Du Loup and Des Plantes, Canada.
The metal iridium is extremely hard, and is used, as well as rhodium, for points to the nibs of gold pens. Its specific gravity is 21.8 .
Laurite. In minute octahedrons. A ruthenium sulphide, with 3 per cent. of osmium. From platinum sands of Borneo and Oregon.

## Palladium.

Isometric. In minute octahedrons. Occurs mostly in grains, sometimes composed of divergent fibres. Color steel-gray, inclining to silver-white. Ductile and malleable. H. $4 \cdot 5-5 . \quad$ G. $=11 \cdot 3-12 \cdot 2$.

Consists of palladium, with some platinum and iridium. Fuses with sulphur, but not alone.

Obs. Occurs in Brazil with gold, and is distinguished from platinum, with which it is associated, by the divergent structure of its grains. It was discovered by Wollaston, in 1803. Selenpalladite, or Allopalladium, is native palladium in hexagonal tables from Tilkerode in the IIartz. It is reported also from St. Domingo and the Urals. Porpezite is palladium gold, or gold containing about 10 per cent. of palladium; three samples assayed at the Rio de Janeiro mint yielding $11 \cdot 1,9 \cdot \%$, and $\% \cdot \%$ per cent. of palladium.

This metal is malleable, and when polished has a whitish steel-like lustre which does not tarnish. A cup weighing $3 \frac{1}{4}$ pornds was made by M. Breant in the mint at Paris, and is now in the garde-meuble of the French crown. In hardness it is equal to fine steel. 1 part fused with 6 of gold forms a white alloy; and this compound was employed, at the suggestion of Dr. Wollaston, for the graduated part of the mural circle constructed by Troughton for the Royal Observatory at Greenwich. Palladium has been employed also for certain surgical instruments.

## MERCURY.

Mercury occurs native; alloyed with silver forming native amalgam ; and in combination with sulphur, selenium, chlorine, or iodine, and with sulphur and antimony in some tetrahedrite. Its ores are completely volatile, excepting when silver or copper is present.

## Native Mercury.

Isometric. Occurs in fluid globules scattered through the gangue. Color tin-white. G. $=13.56$. Becomes solid and crystallizes at a temperature of $-39^{\circ} \mathrm{F}$.

Mercury, or quicksilver, as it is often called (a translation of the old name " argentum vivum)," is entirely volatile before the blowpipe, and dissolves readily in nitric acid.

Obs. Native mercury is a rare mineral, yet is met with at the different mines of this metal, at Almaden in Spain, Idria in Carniola (Austria), in IIungary, Peru, and in California. It is usually in disseminated globules, but is sometimes accumulated in cavities so as to be dipped up in pails.

Mercury is used for the extraction of gold and silver ores. It is also employed for silvering mirrors, for thermometers and barometers, and for various purposes connected with medicine and the arts.
Native Amalgam. See page 117.

> Cinnabar.-Mercury Sulphide.

Rhombohedral. $R \wedge R=\gamma 2^{\circ} 36^{\prime}$. Clearage lateral, highly perfect. Crystals often tabular, or six-sided prisms. Also massive ; sometimes in earthy coatings.

Lustre unmetallic, of crystals adamantine ; often dull. Color bright red to brownish red, and brownish black. Streak scarlet-red. Subtransparent to nearly opaque. H. $=$ 2-2.5. G. $=8.5-9$. Sectile.

Composition. $\mathrm{Hg} \mathrm{S} \mathrm{S}_{2}=$ Sulphur $13 \cdot 8$, mereury $86 \cdot \sim$. It often contains impurities. The liver ore, or lepatic cinnabar, contains some carbon and clay, and has a brownish streak and color. The pure variety volatilizes entirely before the blowpipe.

Diff. Distinguished from red oxide of iron and chromate of lead by vaporizing hefore the blowpipe ; from realgar by giving off on charcoal no alliaceons fumes.

Obs. Cinnabar is the ore from which the principal part of the mercury of commerce is obtained. It is when pure identical with the pigment vermilion. It occurs mostly in connection with siliceous, talcose and argillaceous slates, or other stratified deposits, both the most ancient and thoso of more recent date. The mineral is too volatile to be expected in any ahondance in proper igneous or crystalline rocks, yet has been found sparingly in granite.

The localities are mentioned beyond.
Metarinnabarite is the same compound with cinnabar, but differs in crystallization ; it is from Redington Mine, Lake County, ('aliformia.

Guaduleazarite. of Mexico, is Hg S in which a little of the sulphur is replaced by selenium.

Calomel or Horn Quickilver. A tough, sectile mercury chloride, of a light yellowish or grayish color, and adamantine lustre, translucent or subtranslucent, crystallizing in secoudaries to a square prism. $\mathrm{H} .=1-2 . \quad$ G. $=6 \cdot 48$. It contains $15 \cdot 1$ per cent. of chlorine, and 84.9 of mercury.

Iodic Mereury. A reddish-brown ore, from Mexico.
Tiemannite. A dark steel-gray mercury selenide, from the Hartz, and the vicinity of Clear Lake, ('alifornia.

Coloradinte. A grayish black mercury telluride, with $G .=8 \cdot 627$, from the Keystone and Mountain Lion Mines, Colorado. (Genth.)

Mannolit:: A mercurous tellurate, $\mathrm{Hg} \mathrm{O}+\mathrm{Te}$, from Magnolia district, Colorado.

General Remar'ss.- The following are the regions of the principal mines of mercury. At Idria, in Austria (discovered in 1497), whero the ore is a dark bituminous cinnabur distributed through a blackish shale or slate, containing some native mercury ; at Almaden, in Spain, near the frontier of Estremadura, in the province of La Mancha, in argillaceous beds and grit rock, which are intersected by dikes of "black porphyry" and granite-mines mentioned by Pliny as affording vermilion to the Greeks, 000 years before the Christian era; in the Palatinate on the Rhine; in Hungary; Sweden ; several points in France; Ripa, in Tuscany; in Shensi, in China; at Arqueros, in

Chili ; at Huanca Velica and some other points in Peru; at St. Onofre and other places in Mexico ; in California and Idaho.

The most noted of the Californir mines, New Almaden, is situated in Mine Hill, Santa Clara County, south of San Francisco. The rocks are altered Cretaceous slates, talcose in part, with beds of serpentine either side, and associated also with beds of jasper or siliceous slate. The New Idria mine is in Fresno County, in the Mt. Diablo Kange, and was discovered in 1855 . The rocks are more or less altered silicoargillaceous and siliceons slates and sandstones, and the cinnabar is distributed irregularly through them; between this and the Aurora Mine on San Carlos (the highest peak of the Diablo Range, 4,977 feet), there is much serpentine (in which is chromic iron) and siliceous rock or slate. In Napa Valley, Napa County, north of San Francisco, there are other raluable mines situnted in rocks closely similar, as Whitney states, to those affording quicksilver at New Almaden. They are in a serpentine belt, the cinnabar being in some places in the serpentine, but mostly in the peculiar siliceous rock associated with it. Native mercury occurs with the cinnabar.

The product of the ('alifornia mines of mercury in 1874, is given as follows by Raymond, in his "Mineral Resources for 18\%5":

| New Almaden | Santa Cla | ou | 9,084 flasks. |  |
| :---: | :---: | :---: | :---: | :---: |
| New Idria | Fresno | ' | . . . . . 7,000 | ، |
| Cerro Bronito. |  | " | ... 900 | '، |
| California. | Napa | " | . 3,000 | " |
| Manhattan |  | ، | . 6:0 | ، |
| Phonix. |  | ، | 685 | ، |
| Waskington. |  | " | 200 | ، |
| Redington | .Lake | " | . 7,200 | * |
| California Borax |  | " | . 570 | ، |
| Great Western |  | " | 1,900 | ، |
| Buckeye. | Colusa | " | 700 | ، |
| Missouri. | Sonoma | " | 200 | " |
| Oakland |  | " | 307 | " |
| Saint John. | Solano | " | 1,900 | * |

Which, with the additions from a few other less productive openings, muke a total of 34,254 flasks, or over $2,400,000$ lus. The yield in 1867 was $44,3 \times 6$ flasks, or about $3,400,000 \mathrm{lbs}$. The total yicld of the world in 1872, is stated by Phillips at $6,670,000$ lbs. avoirdupois.

## COPPER.

Copper occurs native in considerable quantitios ; and also combined with oxygen, sulphur, selenium, arsenc, antimony, chlorine, and as carbonate, phosphate, arsenate, sulphate, and vanadate. The ores of copper vary in specific gravity from 3.5 to 8.5 , and seldom exceed 4 in harduess.

## Native Copper.

Isometric. In octahedrons; no cleavage apparent. Often in plates or masses, or arborescent and filiform shapes.

Color copper-red. Ductile and malleable. $\mathrm{H} .=2 \cdot 5-3$. G. $=8 \cdot 84$.

Native copper often contains a little silver disseminated throughout it. Before the blowpipe it fuses readily, and on cooling it is covered with a black oxyd. Dissolves in nitric acid, and produces a deep azure-blue solution on the addition of ammonia.

Obs. Native copper accompanies the ores of copper, and usually oceurs in the vicinity of dikes of igneous rocks.

Siberia, Cornwal, and brazil are noted for the native copper they have produced. A mass, supposed to be from Bahia, now at Lisbon, weighs 2,616 pounds. South of Lake Supesior about Portage Lake on Keweenaw Point, and also, less abundantly, on the Ontanagon River, and at some other points in that region, native copper occurs mostly in veins in trap, and alon in the enclosing sandstone. A mass weighing $3 . \% 04 \mathrm{lhs}$. has been taken from thence to Washington City; it is the same that was figured by Schoolcraft, in the American Journal of Science, volume iii., p.: 201. One large mass was quarried out in the "Cliff Mine." whose weight has been estimated at 200 tons. It was 40 feet long, 6 feet deep, and averaged 6 inches in thickness. This copper contains, intimately mixed with it, about ive per cent. of silver. Besides this, perfectly pure silver, in strings, masses, and grains, is often disseminated through the copper, and some masses, when polished, appear sprinkled with large white spots of silver, resembling, as Dr. Jackson obscrres, a porphyry with its feldepar crystals. (rystals of native copper are also found penetrating masses of prehnite and analcite in the trap rock. This mixture of copper and silver cannot he imitated by art, as the two metals form an alloy when melted together. It is probable that the separation in the rocks is due to the cooling from fusion being so extremoly gradual as to allow the two metals to solidify scparately, at their respective temperatures of solidificationthe trap being an igneous rock, and ages often elapsing, as is well known, during the cooling of a bed of lava, covered from the air. Native copper occurs sparingly in St. Ignace and Michipicoton Islands, Lake Superior.

Small specimens of native copper hare been found in the States of New Jersey, Connecticut, and Massachusetts, where the Triassic formation occurs. One mass from near Somerville, N. J., weighs 78 pounds, and is said originally to have weighed 128 pounds. Within a few miles to the north of New Haven, Coun., one mass of 90 pounds, and another of 200 , besides other smaller, have been found in the drift, all of which came from veins in the trap or associated Triassic sandstone. Near New Brunswick, N. J., a vein or shect of copper, from a sixteenth to an eighth of an inch thick, has been observed and traced along for several rods.
Native copper occurs also in South Australia; it is stated that a single train from the Moonta Mine carried away at one time forty tons of native copper.

Chalcocite-Copper Glance. Vitreous Copper Ore. Redruthite.
Trimetric. $\quad I: I=119^{\circ} 35^{\prime}$. Cleavage
 parallel to $I$, but indistinct. Also in compond crystals like aragonite. Often massive.

Color and streak blackish lead-gray ; often taruished blue or green. Streak sometimes shining. $\mathrm{H} .=2 \cdot 5-3 . \quad \mathrm{G} .=5 \cdot 5-5 \cdot 8$.

Composition. $\mathrm{Cu}_{2} \mathrm{~S}=$ Sulphur $20 \cdot 2$, copper $79 \cdot 8=100$. B. I3. on charcoal gives of fumes of sulphur, fuses easily in the exterior flame ; and after the sulphur is driven off, a globule of copper remains. Inissolves in heated nitric acid, with a precipitation of the sulphur.

Diff. Resembles argentite, but it is not sectile, like that ore, and they afford different results before the blowpipe. The solution of the ore in nitric acid covers an iron plate (or knife blade) with copper, while a similar solution of the silver ore covers a copper plate with silver.

Obs. Occurs with other copper ores in beds and veins. At Cornwall, splendid crystallizations occur. Siberia, Messe, Saxony, the Banat, Chili, etc., afford this ore.

In the United States, a vein affording fine crystallizations occurs at Bristol, Conn. Other localities are at Wolcottville, Simsbury, and Cheshire, Conn. ; at Schuyler's Mines, and elsewhere, N. J. ; in the U. S. copper-mine district, Blue Ridge, Orange County, Virginia; between New Market and Taneytown, Maryland; and sparingly at the copper
mines of Michigan and the Western States; also at some mines north of Lake Huron ; in the San Juan mining region, Colorado; north of Gila Riva, near the borders of New Mexico and Arizona; at the Bruce Mines, Lake Huron, and at Prince's Mine, Spar Island, and on Michipicoton Islands, Lake Superior.

Covellite, or Blue Cipper. A dull blue-black massive mineral, with the composition CuS. $Q=3 \cdot 8$. It contains 66.5 per cent. of copper.

Harrisite. A copper glance with cubic cleavage, from Canton Mine, Ga.; probably a pseudomorph after galeuite.

Chalcopyrite.-Copper Pyrites. Copper-and-Iron Sulphide.
Dimetric. Crystals tetrahedral or octahedral ; sometimes compound. $I \wedge I=109^{\circ} 53^{\prime}$, and $108^{\circ} 40^{\prime}$. Cleavage indistinet. Also massive, and of various imitative shapes.

Color brass-yellow, often tarnished deep yollow, and also iridescent. Streak unmetallic, greenish black, and lout little shining. $\quad \mathrm{H} .=3 \cdot 5-4$. (G. $=4 \cdot 154 \cdot 3$.


Composition. $\mathrm{CuFe} \mathrm{S}_{2}=\mathrm{Sulph}$ ur $34 \cdot 9$, copper $34^{\circ} 6$, iron $30 \cdot 5=100$. Fuses B. B. to a globule which is magnetic, owing to the iron present. Gives sulphur fumes on charcoal. With foda on charcoal affords a globule of metallic iron with copper. The usual effect with nitric acid.

Diff. This ore resembles native gold, and also pyrite. It is distinguished from gold by crumbling when it is attempted to cut it, instead of separating in slices; and from prrite in its deeper yellow color. and in yielding easily to the point of a knife, instead of striking fire with a sted.

Obs. Copper pyrites occurs in veins intersecting gneiss and other metamorphic rocks ; also in those connected with eruptive rocks; and sometimes in cavities or veins in ordinary stratified rocks. It is usually associated with pyrite, and often with galenite, blende, and copper carbonates. The copper of Fuhlun, Sweden, is obtained mostly from this ore, where it occurs with serpentine in gneiss. Other mines of this ore are in the Hartz, near Goslar ; in the Banat, Hungary, Thuringia, etc. The Cornwall ore is mostly of this kind. As prepared for sale at Redruth it rarely yields 12
per cent., and generally only 7 or 8 , and occasionally as little as 3 to 4 per cent. of metal ; " $6 \frac{1}{2}$ per cent. of metal may be considered an average of the produce of the total quantity of ore sold." (Phillips, 1874.) Such poverty of ore is only made up by its facility of transport, the moderate expense of fuel, or the convenience of smelting. Its richness may generally be judged of from the color: if of a fine yellow hue, and yielding readily to the hammer, it is a good ore; but if hard and pale yellow it contains much pyrite, and is of poor quality.

In the United States there are many localities of this ore. It occurs in mines in Vermont, at Strafforl ; and at Shrewsbury, Corinth, Waterbury ; also in New Hampshire, Maine, Massachusetts, and Connecticut; in New York, at the Ancram lead mine ; also near Rossie, and at Wurtzboro' ; in Pennsylvania, at Morgantown ; in Virginia, at the Phenix copper mines, Fauquier County, and at the Walton gold mine, Lazerne County; in Maryland, in the vicinity of Liberty and New London in Frederick County ; and at the Patapseo mines near Sykesville ; in North Carolina, in Davidson and Guilford counties. In Michigan, where native copper is so abundant, this is a rare ore ; but it occurs at Presqu'isle, at Mineral Point, and in Wisconsin, where it is the predominating ore ; in Tennessee, in Polk County, at the Hiwasseo mines; in the San Juan mining region, Colorado ; in Lander Co., and elsewhere, Nevada; at Copperopolis, Calaveras Co., California; also at the Bruce and other mines on Lake Huron ; and Michipicoton Islands, in Lake Superior.
Cubrnite is a copper-and-iron sulphide, containing Sulphur 30.0 , iron $38 \cdot 0$, copper $19 \cdot 8$, silica $2 \cdot 3=90 \cdot 12$.

## Bornite.-Erubescite. Variegated Copper Pyrites.

Isometric. Clearage octahedral in traces. Occurs in octahedrons and dodecahedrons. Also massive.

Color between copper-red and pinchbeck-brown. Tarnishes rapidly on exposure. Streak pale grayish-black and but slightly shining. Brittle. II.=3. G.=5.

Composition. $\mathrm{Cu}_{3} \mathrm{Fe} \mathrm{S}_{3}=$ Sulphur $28 \cdot 6$, copper $55 \cdot 58$, iron $16 \cdot 36$; but varies much.

The ore of Bristol, Conn., afforded Sulphur $25 \cdot 83$, copper $61 \cdot 79$, iron $11 \cdot 7 \%=99 \cdot 39$.
B. B. on charcoal fuses to a brittle globule attractable by
the magnet; dissolves in nitric acid, with separation of sulphur.

Diff. This ore is distinguished from the preceding by its pale reddish-ycllow color, and its rapidly tarnishing and becoming of bluish and reddish shades of color, the quality to which the name erubescite, from the Latin word for to blush, alludes.

Obs. Occurs, with other copper ores, in granitic and allied rocks, and also in stratified formations. The mines of Cornwall have afforded crystallized specimens, and it is there called, from its color, "horse-flesh ore." Other foreign localities of massive varieties are Ross Island, Killarney, Ireland; Norway, Hessia, Silesia, Siberia, and the Banat.

Fine crystallizations were formerly obtained at the Bristol copper mine, Corn., in granite; and also in red sandstone, at Cheshire, in the same State, with malachite and barite. Massive varieties occur at the New Jersey mines, and in Peunsylvania.

Crookesite. A copper selenide, containing 17.25 per cent. of thallium, and a little silver.

Domeykite, Algolonite and Whitneyile are copper arsenides; Berzelianite, a copper selenide; Eucairite, a copper-and-silver selenide.

Tennantite. A compound of copper, iron, sulphur, and arsenic. It occurs in dodecahedral crystals, brilliant, with a dark lead-gray color, and reddish-gray streak. From the Curnish mines near Redruth and St. Day in Curnwall.

> Tetrahedrite.-Gray Copper. Fahlerz.

Isometric and tetrahedral. Occurs in tetrahedral forms. Cleavage octahedral in traces.

Color between steel-gray and ironblack. Streak nearly like the color, sometimes inclined to brown and cherry-red. Rather brittle. II. $=3-$ $4 \cdot 5$. G. $=4 \cdot 5 \cdot 5 \cdot 12$.

Comprosition. $\mathrm{Cu}_{4} \mathrm{~S}_{7} \mathrm{Sb}_{2} \quad\left(=4 \mathrm{Cu}_{3}\right.$ $\mathrm{S}+\mathrm{Sb}_{2} \mathrm{~S}_{3}$ ), but with part of the copper replaced usually by iron and zinc, and sometimes silver or quick-
 silver, and part of the antimony by arsenic, and rarely bismuth. It sometimes contans 30 per cent. of silver in place of part of the copper, and is then called argentiferous tetrahedrite. The amount of arsenic varies from 0 to 10 per cent. One variety from Spain included 10 per cent. of platinum, and another from Hohen-
stein some gold. Specimens from Schwatz, and some other localities, contain 15 to 18 per cent. of morcury, and are called Spaniolite. A kind containing 9 to 13 per cent. of lead and 10 to 13 of silver, has been called Malinowskite.

Obs. The Cornish mines, Andreasberg in the Hartz, Kremnitz in Hungary, Freiberg in Saxony, Kapnik in Transylvania, and Dillenberg in Nassau, afford fine crystallizations of this ore. It is a common ore in the Chilian mines, and it is worked there and elsewhere for copper and often also for silver. Occurs also in Mexico; in Mariposa and Shasta counties, Cal.; abundantly at the Sheba and Do Soto mines, Humboldt Co.; Nerada, near Austin in Lander Co. ; in the San Juan region, Colorado; at the Heintzelman Mine, and the Santa Rita Mine, in Arizona ; also in fine crystallizations in the caves of Huallanca, on the Peruvian Andes, at a height of about 14,700 feet, an ore yielding much silver.
Bournonite. Contains Sulphur $29 \cdot 6$, antimony $25 \cdot 0$, lead $42 \cdot 24$, copper $13 \cdot 0=100$. Its crystals are modified rectangular prisms, of a steelgray color and streak, and are often compounded into shapes like a cog-wheel, whence it is called zoherl-ore. $\mathrm{H} .=2 \cdot 5-3$. G. $=5 \% 66$. From the Tyrol, Hartz, Transylvania, Saxony, Cornwall, and Siberia.
Other sulphantimonites or sulpharsenites of copper are Chalcostibite, Emplectite, Binnite, Stylotypite, Aikinite, Enargite, Pulybasitc. Polybasite contains also silver.

## Atacamite.-C'opper Oxichloride.

Trimetric; in rhombic prisms and other forms; also granular massive. Color green to blackish green. Lustre adamantine to vitreous. Streak apple-green. Translucent to subtranslucent. $\quad$ II. $=3-3 \cdot 5 . \quad \mathrm{G} .=3 \cdot 75-3 \cdot 9$. Cumposition, $\mathrm{Cu} \mathrm{Cl}+3 \mathrm{Cu} \mathrm{O}_{2} \mathrm{H}_{4}=$ Chlorine $16 \cdot 64$, oxygen $11 \cdot 25$, copper $11 \cdot 25$, water $12 \cdot 66=100$. From the Atacama desert, between Chili and Pern, and elewhere in Chili ; also from Bolivia, Vesuvius, Saxony, Spain, Cornwall.

> Cuprite.-Red Copper Ore.

Isometric. In regular octahedrons, and modified forms of the same. Cleavage octahedral. Also massive, and sometimes carthy.

Color deep red, of various shades. Streak brownish red. Lustre adamantine or submetallic ; also earthy. Subtransparent to nearly opaque. Brittle. H. $=3 \cdot 5-4 . \quad$ G. $=5 \cdot 85-$ $6 \cdot 15$.

Composition. $\mathrm{Cu}_{2} \mathrm{O}=$ Oxygen $11 \cdot 2$, copper $88 \cdot 8$. B. B. on charcoal, yields a globule of copper. Dissolves in nitric acid. The earthy varieties have been called tile ore, from the color.


Diff. From cinnabar it differs in not being volatile before the blowpipe; and from red iron ore in yielding a bead of copper on charcoal, and copper reactions.

Obs. Occurs with other copper ores in the Banat, Thuringia, Cornwall, at Chessy near Lyons, in Siberia, and Brazil. The octabedrons are often green, from a coating of malachite.

In the United States, it has been observed crystallized and massive at Schupler's, Somerville, and the Flemington copper mines, N. J.; also near New Brunswick, N. J.; at Bristol, Conn.; near Ladenton, Rockland County, N. Y.; in the Lake Superior region.

Tenorite, Melaconite, or Black Copper. An oxide of copper, CuO, occurring as a black powder, and in dull black masses and botryoidal concretions, in veins or along with other copper ores; also in iron-gray flexible scales, in the Vesuvian lavas. It is an abundant ore in some of the copper mines of the Mississippi Valley, and yields 60 to 70 por cent. of copper. It results from the decomposition of the sulphides and other ores. At the Hiwassee Mine, Polk Co., Tennessce, it has been abundant. It was formerly found of excellent quality in the Lake Superior copper region.

## Chalcanthite.-Blue Vitriol. Sulphate of Copper.

Triclinic. In oblique rhomboidal prisms. Also as an eflorescence or incrustation, and stalactitic.

Color deep sky-blue. Stroak uncolored. Subtransparent to translucent. Lustre vitreous. Soluble, taste mauseous and metallic. $\mathrm{H}=2-2 \cdot 5 . \quad G .=2 \cdot 21$.

Composition. $\mathrm{Cu} 0, \mathrm{~S}+5 \mathrm{aq}=$ Sulphuric acid (or sulphur trioxide) $32 \cdot 1$, copper oxide $31 \cdot 8$, water $36 \cdot 1$. A polished plate of iron in solutions becomes covered with copper.

Obs. Occurs with the sulphides of copper as a result of their decomposition, and is often in solution in the waters flowing from copper mines. Occurs in the Hartz, at Fahlun in Sweden, and in many other foreign copper regions; in the Hiwassee copper mine, Tennessee; the Canton mine, Georgia ; at Copiapo, Chili.

Blue vitriol is much used in dyeing operations and in the printing of cotton and linen ; also for various other purposes in the arts. It has been employed to prevent dry rot, by steeping wood in its solution : and it is a powerful preserrative of animal substances; when imbued with it and dried, they remain unaltered. It is afforded by the decomposition of copper pyrites, in the same manner as green vitriol from iron pyrites; but it is manufactured for the arts, chiefly from old sheathing-copper, copper turnings, and copper refinery ecales.

In Frederick County, Maryland, blue ritriol is made from a black earth which is an impure oxide of copper with copper pyrites.

In some mines, the solution of sulphate of copper is so abundant as to afford considerable copper, which is ohtained by immersing clean iron in it, and is called copper of cementation. At the copper springs of Wicklow, Ireland, about 500 tons of iron were laid at one time in the pits; in about 12 months the bars were dissolved, and every ton of iron yielded a ton and a half, and sometimes nearly two tons, of a precipitated reddish mud, each ton of which produced 16 cwt. of pure copper. The Rio Tinto Mine in Spain is another instance of working the sulphate in solution. These waters yield annually $1,800 \mathrm{cwt}$. of eopper, and consume $2,400 \mathrm{cwt}$. of iron.

Brochantite. An insoluble copper sulphate, containing $17 \% 7$ per cent. of sulphur trioxide. Color emerald-green. In tabular rhombic crystals, from the Urals, Retzbanya, Cornwall, Mexico, Chili, Australia. Krisuvigite and Konigite are the same species.
Langite, Cyanotrichite (Velvet copper ore), Krönkite, Philippite, Enysite, Linarite, Dolerophanite, Hydrocyanite, are other sulphates containing copper, the last two anhydrous; and Connellite is another containing chlorine, from Cornwall.
The Copper tungstate, Cuprotungstite, occurs of a fellowish-green color in Chill.

## Olivenite.-Hydrous Copper Arsenate.

Trimetric. $\quad I \wedge I=92^{\circ} 30^{\prime}$. In prismatic crystals, and also fibrous and granular massive. Olive-green, and of other greenish shades, to liver and wood-brown. Streak olive-green to brown. Substransparent to opaque. Brittle. $\mathrm{H} .=3 . \quad$ (.$=4 \cdot 1-4 \cdot 4$.

Composition. $\mathrm{Cu}_{4} \mathrm{O}_{9} \mathrm{As}_{2}=$ Arsenic pentoxide $40 \cdot 66$, copper oxide $56 \cdot 15$, water $3 \cdot 19=100$. Fuses very easily, coloring the flame bluish green. B.B. fuses with deflagration, giving off arsenical furnes, and affords a brittle globule, which with soda yields metallic copper.

Obs. From Cornwall, the Tyrol, Siberia, Chili, and other places.

Besides the above, there are the following salts of copper:
Cupper Arsenates.- Euchroite has a bright emerald-green color, and contains 83 per cent. of arsenic acid, and 48 of oxide of copper ; occurs in modified rhombic prisms; $\mathrm{H}=3 \cdot 75 ; \mathrm{G}=3 \cdot 4$; from Libethen, in Hungary. (liuorlasite (Aplancsite) is of a dark verdigris-green inclning to blue, and also dark blue; $\mathrm{H} .=2 \cdot 5-3 ; \mathrm{G} .=4 \cdot 19-4 \cdot 36$. It contains $6 \cdot \cdot 7$ per cent. of copper oxide; from Cornwall. Erinite has an emerald-green color, and occurs in mammillated coatings ; $\mathrm{HI} .=4.5-5 ; \mathrm{G} .-\mathrm{F} .4 .04$; contains 50.4 per cent. of copper oxide ; from limerick, Ireland. Liroca. uite varies from sky-blue to verdigris-green ; occurs in rhombic prisms, sometimes an inch broad; $\mathrm{H}=2-2 \cdot 5 ; \mathrm{G} .=3 \cdot 8-3 \cdot 98$. Chulcophyllit: (eopper mict is remarkable for its thin foliated or mica-like structure; color emerald or grass-green ; H. $=2 ; \mathbf{G}=2 \cdot 55$. ('ontains 58 per centof copper oxide; from Cornwall and Hungary. Tyrolite (Copper froth is another arsenate of a pale apple-green and verdigris-green color ; it has a perfect cleavage ; it contains 43.9 per cent. of copper oxide ; from Ilungary, Siberia, the Tyrol, and Derbyshire. Corneallite and Chlorotile, are names of other copper arsenates. These different arsenates of copper give an alliaceous odor when heated on charcoal before the blowpipe.

Copper Phosphates. - Pseudomalachite (Phosphochakite, Ehlite, Di hydrite) occurs in very oblique crystals, or massive and incrusting, and has an emerald or blackish -green color; $\mathrm{H} .=45-5 ;(\mathrm{G} .=4.34 ;$ contains 64 to 70 per cent. of copper oxide; from near Bonn, on the Rhine, and also from Hungary. Libethenite has a dark or olive-green color, and occurs in crystals, usually octahedral in aspect, and massive ; $\mathrm{H} .=$ 4 ; G. $=8 \cdot 6-3.8$; contains $66 \cdot 5$ per cent. of oxide of copper; from Hungary and Cornwall. Other copper phosphates are Veszelyite, Thgilite, Isoclasite. Torbrrnite is a copper-and-uranium phosphate. These phosphates give no fumes before the blowpipe, and have the reaction of phosphoric acid.

Copper Vanalates. - Folborthite is a copper-and-calcium vanadate from the Urals; and Mottrammite and Psittacinite, copper-and-lead vanadates, the former from England, and the latter from gold mines in Silver Star district. Montana.

Rivotite. Yellowish-green copper antimonate and carbonate.

## Malachite.-Green Copper Carbonate.

Monoclinic. Usual in incrustations, with a smonth tuberose, botryoidal, or stalactitic surface; structure finely and firmly fibrous. Also earthy.

Color light green, streak paler. Usually nearly opaque ; crystals translucent. Lustre of crystals adamantine inclining to vitreous; but fibrous incrustations silky on a cross fracture. Earthy varieties dull. $\mathrm{H} .=3 \cdot 5-4$. G. $=3 \cdot \%-4$.

Composition. $\mathrm{Ca}_{9} \mathrm{O}_{4} \mathrm{C}+\mathrm{H}_{2} \mathrm{O}=$ Carbon dioxide (or carbonic acid) $19 \cdot 9$, copper oxide $71 \cdot 9$, water $8 \cdot 2=100$. Dissolves with effervescence in nitric acid.
B.B. decrepitates and blackens, colors the flame green, and becomes partly a black scoria. With borax it fuses to a deep-green globule, and ultimately affords a bead of copper.

Diff. Readily distinguished by its copper-green color and its associations with copper ores. It resembles a siliceons ore of copper, chrysocolla, a common ore in the mines of the Mississippi Valley; but it is distinguished by its complete solution and effervescence in nitric acid. The color also is not the bluish green of chrysocolla.

Obs. Green malachite usually accompanies other ores of copper, and forms incrustations, which, when thick, have the colors banded and delicate in their shades and blending. Perfect crystals are quite rare. The mines of Siberia, at Nischne Tagilsk, have afforded great quantities of this ore. A mass, partly disclosed, measured at top 9 feet by 18 ; and the portion uncovered contained at least half a million pounds of pure malachite. Other noted foreigu localities are Cheser, in France; Sandlodge, in Shetland; Schwatz in the Tyrol ; Cornwall ; the Island of Cuba; Serro do Bembe, west coast of Africa; copper mines of Australia; Chili.

The copper mine of Cheshire, Conn., has afforded handsome specimens ; also Morgantown, Perkiomen, and Phœnixville, Penn. ; Scluyler's Minc, and the New Brunswick copper mine, N. J.; it occurs also in Maryland, between Newmarket and Taneytown ; and in the Catoctin Mountains; in the Blue Ridge, Penn., near Nicholson's Gap ; also in ntic district, Utah.
TiAt Mineral Point, Wisconsin, a bluish silico-carbonate of ocpper occurs, which is for the most part chrysocolla, or a mixture of this mineral with the carbonato.

This minoral receives a high polish and is used for tables, mantelpicces, vases ; and also ear-rings, snuff-boxes, and various ornamental articles. It is not much prized in jewelry. At Versailles there is a room furnished with tables, vases, and other articles of this kind ; and similar rooms are to be found in many European palaces.

Malachite is sometimes passed off in jewelry as turquois, though easily distinguished by its shade of color and much inferior hardness. It is a valuable ore when abundant ; but it is seldom smelted alone, because the metal is liable to escape with the liberated volatile ingredient.

## Azurite.-Blue Copper Carbunate. Blue Malachite.

Monoclinic. In modified oblique rhombic prisms, the crystals rather short and stout; lateral cleavage perfect. Also massive. Often earthy.

Color deep bluo, azure blue, Berlin blue. I'ransparent to nearly opaque. Streak bluish. Lustre vitreons, almost adamantine. Brit-


Composition. $\mathrm{Cu}_{3} \mathrm{O}_{7} \mathrm{C}_{2}+\mathrm{I}_{2} \mathrm{O}=$
 Carbon dioxide $25 \cdot 6$, copper oxide $69 \cdot 2$, water $5 \cdot 2$. B. B. and in acids like the preceding.

Obs. Azurite accompanies other ores of copper. Chessy, France, has afforded fine crystals; found also in Sibcria; in the Banat ; near Redruth in Cornwall ; at Phonixville, Pa., in crystals ; in Wisconsin near Mineral Point ; as incrustations, and rarely as crystals, near Sing Sing, N. Y.; near New Brunswick, N. J.; near Nicholson's Gap, in the Blue Kidge, Pa.

When abundant it is a valuable ore of copper. It makes a poor pigment as it is liable to turn green.

Aurichalcite (Buratite) is a hydrous copper-and-zinc carbonate, or a cuprous hydrozincite, pale green to sky-blue in color ; from the Altai, Retzbanya, Chessy in Frauce, Tyrol, Spain, Leadhills in Scotland, and Lancaster, Pa.

Dioptase-COpper Silicate.
Rhombohedral. $\quad R \wedge R=126^{\circ} 24^{\prime}$. Occur: in six-sided prisms with rhombohedral terminations. Color emeraldgreen. Lustre vitreous. Transparent to nearly opaque. - G. $=3 \cdot 28-3 \cdot 35$.

Composition. $\mathrm{CuIH}_{2} \mathrm{O}_{4} \mathrm{Si}=$ Silica $38 \cdot 1$. copper oxide $50 \cdot 4$, water $11 \cdot 5=100$. B.B. with soda on charcoal yields copper, and this, with its hardness, distinguishes it from the species it resembles.

Ols. From the Khirgeez Steppes of Siberia.

> Chrysocolla.-Hydrous Copper Silicate.

Usually as incrustations; botryoidal and massirc. Also in thin seams and stains; no fibrous or granular structure apparent, nor any appearance of crystallization.
Color bright green, bluish green. Lustre of surface of incrustations smoothly shining; also earthy. Translucent to opaque. $\mathrm{H} .=2-4 . \quad \mathrm{G} .=2-2 \cdot 4$.

Composition. $\mathrm{CuO}_{3} \mathrm{Si}+2 \mathrm{aq}=$ Silica $34 \cdot 2$, copper oxide $45 \cdot 3$, water $20 \cdot 5=100$.


The mineral raries much in the proportion of its constituents, as it is not crystallized.
B.B. it blackens in the inner flame, and vields water without melting. With soda on charcoal yields a globule of copper.

Diff. Distinguished from green malachite as stated under that species.

Obs. Accompanies other copper ores in Cornwall, Hungary, the Tyrol, Siberia, Thuringia, etc. In Chili it is abundant at the various mines. In Wisconsin and Missouri it is so abundant as to be worked for copper. It was formerly taken for green malachite. It also occurs at the Somerville and Schuyler's mines, N. J., at Morgantown, Penn., and Wolcottville, Conn.
This ore in the pure state affords 30 per cent. of copper; luat as it occurs in the rock will hardly yield one-third this amount. Still, when abundant, as it appears to be in the Mississippi Valley, it is a valuable ore.

General Remarks.-The most valuable sources of copper for the arts are native copper, chalcopyrite or "yellow copper ore", ( or "copper clance," bornite or "variegated copper ore,"
or " graen carbonate of copper." chrysocolla or " silicate," cuprite or "red oxide of copper ; " and occasionally tenorite or " black copper."

The principal copper regions, exclusive of the American, are as follows. The Cornwall and Devon, England, where the ore is mostly chalcopyrite ; about Mansfeld, in Prussia, having the ore distributed through a bod of red shale in the Permian (Kupferschiefer), about eighteen inches thick, making about 21 per cent. of the bed; the Urals on their western slope, in the Permian, as in Mansfeld; also more productively on the eastern side of the Urals, at the Nischne Tagilsk and Bogoslowskoi mines, in Silurian limestone where traversed by eruptive rocks, and at the Gumeschewskoi mine, in argiliaceous shale, the ore chiefly malachite and cuprite; in France, at Chessy, near lyons, of malachite and azurite, now of little value; in Norway, at Alten, and in Sweden, at Fahlun; in Hungary, at Schem nitz, Kremnitz, Kapnik, and the Banat ; in Italy, at Monte Catini, in Spain, in the province of Huelva, where is the Rio Tinto mme, which affords chalcopyrite, and also the sulphate (p. 138) ; in Portugal, at San Doiningo, near the mouth of the Guadiana; in Algeria, Turkey, China, Japan, Cape of Good Hope; in South Australia, where are three prominent mines, the Burra, Wallaroo, and Moonta, their yield in $18 \% 5, £ 451,000$; New South Wales, the yicld in 1875 , about 6,000 tons, the value $£ 508,800$.

In South America, in Chili, in the vicinity of Copiapo, and less abundantly at other places to the south; in Bolivia, also in Peru, and the Argentine Republic, but, not much developed. In Cuba, but much less yroductive than formerly.

In Eastern North America, some copper has been afforded by the Triassic of New Jersey and the Connecticut Valley, but there are no producing mines. Corinth, Vermont, and the Hiwassee mine, Tennessere, are worked. The chief sources of copper are the reins of Northern Michigan, near Lake Superior. The veins are connected with trap-dikes intersecting a red Lower Silurian sandstone as stated on page 131. The first discoveries of copper ore were made at Copper Harbor. Near Fort Wilkins the black oxide was afterward found in a large deposit, and 40,000 pounds of this ore were shipped to Boston. On further exploration in the trap, the Cliff mine, 25 miles to the westward, was laid open, where the largest masses of native copper have been found, and which still proves to be highly productive. Other veins have since been opened in various parts of the region, at Eagle Harbor, Eagle River, Grand Marais, Lac La Belle, Agate Harbor, Torch Lake, on the Ontonagon, in the Porcupine Mountains, and elsewhere. The country north of Lakes Superior and Huron, Isle Rovale and the Michipicoton Islands, in Lake Superior, also nfford copper ores, and the vicinity of Queber at the Acton and Harvey Hill mines, in rocks referred to the Quebec formation.

In Western North America, in Arizona, there are large veins of copper north of the Gila, on the borders of New Mexico, where are the Santa Rita and Hanover mines, and the ores aro cuprite, chalcocite, malachite, there are rich veins also in Colorado, especially in Gilpin and Park counties, in Nevada, and California.

The amount of copper produced in 18\%2, is stated as follows by J. Artur Phillips (Elements of Metallurgy) :

| England. | 5,600 tons. |
| :---: | :---: |
| Prussia. | 8,000 $\cdot$ |
| Russia | 6,500 |
| Hungary. | 3,500 |
| Sweden and Norway | 2,500 |
| Spain. | 7,500 |
| Portugal. | 5,500 |
| Japan. | 1,000 |
| South Australia. | 12,000 |
| South Africa | 7,500 |
| Chili and Bolivia. | 46,500 " |
| United States. | 12,000 |

The total annual production is estimated by Phillips at 126,000 to 130,000 tons.

The metal copper was known in the carliest periods and was used mostly alloyed with tin, forming bronze. The mines of Nubia and Ethiopia are believed to have produced a great part of the copper of the early Egyptians. Eubæa and Cyprus are also mentioned as affording this metal to the Greeks. It was employed for cutting instruments and weapons, as well as for utensils; and bronze chisels are at this day found at the Egyptian stone-quarries, that were once employed in quarrying. This bronze (chalhiss of the Greeks, and as of the Romans) consisted of about 5 parts of copper to 1 of tin, a proportion which produces an alloy of maximum hardness. Nearly the same material was used in carly times over Europe; and weapons and tools have been found consisting of copper, edged with iron, iudicating the scarcity of the latter metal. Similar weapons have also been found in Britain ; yet it is cortain that iron and steel were well known to the Romans and later Greeks, and to some extent used for warlike weapons and cutlery. Bronze is hardened by hammering or pressure.

Copper knives, axes, chisels, spear heads, bracelets, etc., have been found in the Indian Mounds of Wisconsin, Illinois, and the neighboring States; and there is evidence that the Indians, besides using drift masses of copper, knew of the copper veins of Northern Michigan, and worked them, especially in the Ontonagon region, where their tools and excavations have been discovered.

Copper at the present day is very various in its applications in the arts. It is largely employed for utensils, for the sheathing of ships, and for coinage. Alloyed with zinc it constitutes brass, and with tin it forms bell-metal as well as bronze.

Brass consists of copper 65 per cent., zinc 35 ; with 53.5 per cent. of zinc the alloy is silver-white; casting brass of 65-72 copper, 35-28 zinc ; or molu or Dutch metal, of 70-85 copper, 15-25 zinc, with 03 of each, lead and tin ; brass for lathe-work of $60-70$ copper, 28-38 zinc, 2 lead; Muntz metal, for the sheathing of ships, 60 copper, 39 zinc, 1 lead; spelter solder for brass, copper 50, zinc 50.

Bronze for medals consists of copper 93 , tin 7 ; for speculum metal, copper 60, tin 30, arsenic 10 ; for casting bronze, copper 82-83, tin 1-3, zinc $17-18$; for gun-metal, copper $85-92$, tin $8-15$; for boll-metal, copper $65-80$, tin $20-35$, antimony $0-2$; antique bronze, copper 67-95, tin 8-15, lead 0-1, zinc 0-16.

Lord Rosse used for the speculum of his great telescope, 126 parts
of copper to $5 \% \frac{1}{4}$ parts of tin. The brothers Keller, celebrated for their statue castings, used a metal consisting of 914 per cent. of copper, 5.53 of zinc, 17 of tin, and 1.37 of lead. An equestrian statue of Louis XIV., 21 feet high, and weighing 53,263 French pounds, was cast by them in 1699, at a single jet.

An alloy of copper 90 , and aluminum 10 , is sometimes used in place of bronze.

## LEAD.

Lead occurs rarely native; generally in combination with sulphur ; also rarely with arsenic, tellurium, selenium, and in the condition of sulphate, carbonate, phosphate and arsenate, chromate and molybdate.

The ores of lcad vary in specific gravity from $5 \cdot 5-8 \cdot 2$. They are soft, the hardness of the species with metallic lustre not exceeding 3 , and others not over 4 . They are casily fusible before the blowpipe (excepting plumbo-resinite); and with soda on charcoal (and often alone), malleable lead may be obtained. The lead often passes off in yellow fumes, when the mineral is heated on charcoal in the outer flame, or it covers the charcoal with a yellow coating.

## Native Lead.

A rare mineral, occurring in thin laminæ or globules, G. $=11 \cdot 35$. Said to have been seen in the lava of Madeira; at Alston in Cumberland with galena; in the County of Kerry, Ireland; in an argillaceous rock at Carthagena; at Camp Creek, Montana.

> Galenite.-Galena. Lead Sulphide.

Isometric. Cleavage cubic, eminent, and very easily obtained. Also coarse or fine granular ; rarely fibrous.

2.

3.


Color and streak lead-gray. Lustre shining metallic. Fragile. H. $=2 \cdot 5 . \quad G .=7 \cdot 25-7 \%$.

Composition. $\mathrm{PbS}=$ Sulphur $13 \cdot 4$, lead $86 \cdot 6=100$. Often contains some silver sulphide, and is then called argentiferous galena; and at times zinc sulphide is present. The ore of veins intersecting crystalline motamorphic rocks is most likely to be argentiferous. The proportion of silver varies greatly. In Europe, when it contains only 7 or 8 ounces to the ton it is worked for the silver. The galenite of the Hartz affords 03 to 05 per cent. of silver ; the English 00 to $\cdot 03$ per cent. ; that of Leadhills, Scotland, 03 to 00 ; that of Pike's Peak, Colorado, '05 to $\cdot 06$; that of Arkansas, $\cdot 03$ to $\cdot 05$; that of Middletown, Ct., 15 to $\cdot 20$; that of Roxbury, Ct., 1.85 ; that of Monroe, Ct., 3.0 ; while that of Missouri afforded Dr. Litton only 0012 to 0027 per cent. A little antimony or cadmium is sometimes present.
B.B. on charcoal, it decrepitates unless heated with caution, and fuses, giving off sulphur, coats the coal yellow, and finally yields a globule of lead.

Diff. Galenite resembles some silver and copper ores in color, but its cubical cleavage, or granular structure when massive, will usually distinguish it. Its reactions before the blowpipe show it to be a lead ore, and a sulphide.

Obs. Galena occurs in granite, limestone, argillaceous and sandstone rocks, and is often associated with ores of zinc, silver and copper. Quartz, barite, or calcite is generally the gangue of the ore; also at times fluor spar. The rich lead mines of Derbyshire and the northern districts of England, occur in the Subcarboniferous limestone; and the same rock contains the valuable deposits of Bleiberg, in Austria, and the neighboring deposits of Carinthia. The ore of Cornwall is in true veins intersecting slates and is argentiferous. At Freiberg in Saxony, it occupies veins in gneiss; in the Upper Hartz, and at Przibram in Bohemia, it traverses clay slate, of Lower Silurian age ; at Sahla, Sweden, it occurs in crystalline limestone. There are other valuable beds of galena, in France at Poullaouen and Huelgoet, Brittany, and at Villefort, department of Lozere; in Spain in the granite and argillyte hills of Linares, in Catalonia, Grenada, and elsewhere ; in Savoy; in Netherlands at Vedrin, not far from Namur; in Bohemia, southwest of Prague ; in Joachimstahl, where the ore is worked principally for its silver; in Siberia in the Daouria Mountains in limestone, argentiferous and worked for the silver.

The deposits of this ore in the United States are remark-
ably for their extent. They occur in limestone, in the States of Missouri, Illinois, Iowa, and Wisconsin ; argillaceous iron ore, pyrite, calamine and smithsonite ("dry bone" of the miners), blende ("black-jack"), carbonate of lead or cerussite, and barite or heavy spar, are the most common associated minerals; and less abundantly occur chalcopyrite and malachite, ores of copper ; also occasionally the lead ores, anglesite and pyromorphite; and in the Mine La Motte region, black cobalt, and linnæite an ore of nickel.

Lead ore was first noticed in Missouri in $1 \% 00$ and 1701. In 1720 the mines were rediscovered by Francis Renault and M. La Motte ; and the La Motte bears still the name of the latter. Afterward the country passed into the hands of Spaniards, and during that period, in 1763, a valuable mine was opened by Francis Burton, since called Mine à Burton.

The lead region of Wisconsin, according to Dr. D. D. Owen, comprises 62 townships in Wisconsin, 8 in Iowa, and 10 in Illinois, being 87 miles from cast to west, and 54 miles from north to south. The ore, as in Missouri, is abundant, and throughout the region there is scarcely a square mile in which traces of lead may not be found. The principal indications in the eyes of miners, as stated by Mr. Owen, are the following : fragments of calcite in the soil, unless very abundant, which then indicate that the vein is wholly calcareous or nearly so ; the red color of the soil on the surface, arising from the ferruginous clay in which the lead is often imbedded; fragments of lead ("gravel mineral"), along with the crumbling magnesian limestone, and dendritic specks distributed over the rock; also, a depression of the country, or an elevation, in a straight line ; or "sinkholes ; " or a peculiarity of vegetation in a lincar direction. The ore, according to Whitney, occupies chambers or openings in the limestone instead of true reins, and in this respect it is like that of Derbyshire and Northern England.

The mines of Wisconsin and Illinois are in Lower Silurian limestone of the Trenton period, called the Galena limestone; those of Southeastern Missouri, situated chiefly in Franklin, Jefferson, Washington, St. François, St. Génevieve, and Madison counties, are in the "Third Magnesian limestone ;" also Lower Silurian, but, of the Calciferous or Potsdam period; those of Sonthwestern Missouri, situated mostly in Newtown, Jasper, Lawrence, Green and Dade counties, and in the western part of McDonald, Barry,

Stone, and Christian counties, are in the "Kcoknk limestone," of the Subcarboniferous period, but partly in Webster, Taney, Christian, and Barry counties, in the Lower Silurian "magnesian limestone;" those of Central Missouri, situated in Moniteau, Cole, Miller, Morgan, and other counties, are mostly in the Lower Silurian "magnesian limestonc," but partly, as in Northern Moniteau, in the Subcarboniferous. The conditions in which the ore occurs in Missouri confirms the opinion of Prof. Whitney, as to there being no true reins. Mr. Adolf Schmidt, in his account of the Missouri lead ores, says that the deposits contain red clay, broken chert, from the chert bed, and portions of the limestone beds, along with the lead ; that the barite was introduced after the lead; that some caves are filled through all their ramifications, while others are only partly filled; and he adds that the same solvent waters that made the cares and horizontal fissures or openings may have held the various minerals in solution. In Derbyshire, England, the deposits contain fossils of Permian rocks, showing that, although occurring in Subcarboniferous limestone, they were much later in origin.

Galenite also occurs in the region of Chocolate River and elsewhere, Lako Superior copper region; on Thunder Bay, and Black Bay ; at Cave-in-Rock in Illinois, along with fluorite; in New York at Rossie, St. Lawrence County, in gneiss, in a vein 3 to 4 feet wide; near Wurtzboro' in Sullivan County, a large vein in millstone grit ; at Ancram, Columbia County ; Martinsburg, Lewis County, N. Y., and Lowville; in Maine, at Labec; also of less interest at Blue Hill Bay, Birmingham and Parsonsfield ; in New Hampshire, at Eaton, Bath, Tamworth and Haverhill ; in Vermont, at Thetford; in Massachusetts, at Southampton, Leverett, and Sterling, but without promise to the miner; at Newburyport, Mass., in a rein which is now worked ; at Middletown, Ct., formerly worked as a silver-lead mine ; in Virginia, in Wythe County, Louisa County, and elsewhere ; in North Carolina, at King's Mine, Davidson County, where the lead appears to be abundant; in Tennessee, at Brown's Creek, and at Haysboro', near Nashville; in Pennsylvania, at Phœnixville ; in Michipicoton and Spar Islands, Lake Superior. In Nevada it is abundant on Watkins River, and at Steamboat Springs, Galena district ; in Colorado, at Pike's Peak, etc.; in Arizona, in the Patagonian Mts., Santa Mita

Mts., and in Yuma County ; in the Castle Dome, Eureka, and other districts, where the ore is worked for the silver it contains.

The lead of commerce is obtained from this ore. It is also employed in glazing common stoneware: for this purpose it is ground up to an impalpable powder and mixed in water with clay; into this liquid the earthen vessel is dipped and then baked.

## Lead Selenides and Tellurides.

These various ores of lead are distinguished by the fumes before the blowpipe, and by yielding, on charcoal, ultimately, a globule of lead.

Clausthalite, or lead selenide, has a lead-gray color, and granular fracture, and is occasionally foliated. $\mathrm{H} .=2 \cdot 6-3 . \mathrm{G}=7 \cdot 6-8 \cdot 8$. B. B. on chareoal a horse-radish odor (that of sclenium). From the Hartz. There is a lead and copper selenide (Zorgite) which has the sp. gr. $7-7 \%$. A lead-ard-mercury selenide (Lehirbachite) occurs in foliated grains or masses of a lead-gray to bluish and iron-black color.

Altaite, or lead telluride. A tin-white cleavable mueral, with $\mathrm{H} .=3$ $-\mathbf{3} \cdot 5$, and $\mathbf{G} .=816$. From the Altai Mountains.

Nugyagite, or Foliated tellurium, is a less rare species, remarkable for being foliated like graphite; color and streak blackish lead-gray ; II. $=1-10^{\circ}$, G. $=7 \cdot 085^{\circ}$. It contains Tellurium $32 \cdot 2$, lead $54^{\circ} 0$, gold $9 \cdot 0$, with often silver, copper, and some sulphur. From Transylvania.

Antimonial and Arsenical Sulphides of lead. These include Sartorite, Zinkenite, Plagionite, Jumcsonite, Dufrenoysite, Boulangerite, Kobellite, Mcueqlinite, Geocronite; also Brongniardite and lreieslebenite, in which silver is also present, and Stylotypite and Aikenite in which copper is also present.

## Minium.-Oxide of Lead.

Pulverulent. Color bright red, mixed with yellow. G. $=$ $4 \cdot 6$. Composition, $\mathrm{Pb}_{3} \mathrm{O}_{4}$. Affords globules of lead in the reduction flame of the blowpipe.

Obs. Occurs at various mines, usually associated with galena, and is found abundantly at Austin's Mines, Wythe County, Virginia, with white lead ore.

Uses. Minium is the red lead of commerce; but for the arts it is artificially prepared.
Plumbic ochre is lead protoxide, of a yellow color.
Mendipite. Color white, yellowish or reddish, nearly opaquo. Lustre pearly. $\mathrm{G} .=7-7 \cdot 1 . \quad \mathrm{PbCl} 2+\mathrm{PbO}=$ Chloride of lead $38 \cdot 4$, lead oxide 616 . From Mendip Hills, Somersetshire. Cotunnite is a chloride of lead, $\mathrm{PbCl}_{2}$, occurring at Vesuvius in white acicular crystals. It contains $74 \cdot 5$ per cent. of lead.

Plumbogummite. In globular forms, having a lustre somewhat like gum arabic, and a yellowish or reddish-brown color. H.
G. $=6.3-6.4$. Also a variety 4-4.9. Consists of lead, alumina, and water. From Huelgoet in Brittany, and at a lead mine in Beaujeu; also from the Missouri mines, with black cobalt, and from Canton mine, Ga.

Anglesite.-Lead Sulphate.
Trimetric. In rhombic prisms


PIIGENTXVILLE. and other forms. Lateral cleavage. $I \wedge I=103^{\circ} 43 \frac{1^{\prime}}{}$. Also massive ; lamellar or granular.

Color white or slightly gray or green. Lustre adamantine ; sometimes a litte resinous or vitreous. Transparent to nearly opaque. Britthe. H. $=2 \cdot 75-3, \quad \mathrm{G} .=6 \cdot 1-6 \cdot 4$.

Composition. $\mathrm{Pb} \mathrm{O}_{4} \mathrm{~S}$, affording about 73 per cent. of oxide of lead. B.B. fuses in the flame of a candle, and, on charcoal, yields lead with soda.
Diff: Rescmbles aragonite and some other earthy species; but this and the other ores of lead are at once distinguished by specific gravity, and also by their yielding lead in blowpipe trials. Differs from the carbonate of lead in lustre and in not dissolving with efferrescence in acid.

Obs. Usually associated with galena, and results from its decomposition. Occurs in fine crystals at Leadhills and Wanlockhead, Great Britain, and also at other foreign lead mines. In the United States, it is foumd at the lead mines of Missouri and Wisconsin ; in splendid crystallizations at Phœenixville, Pa.; sparingly at the Walton gold mine, Louisi County, Va.; at Southampton, Mass.; in Arizona, and in Cerro Gordo, Cal.

Caledonite is a lead-and-copper sulphate, of azure-blue color. It is remarkable for a very perfect clearage in one direction. $G .=64$. From Leadhills and Roughten Gill, England; also from Mine la Motte, Missouri.
Lead selenate. A sulphur-yellow mineral, occurring in small globules, and affording before the blowpipe on charcoal a garlic odor, and finally a globule of lead. It is named Kerstenitc.

> Crocoite.-Crocoisite. Lead Chromate.

Monoclinic. In oblique rhombic prisms, massive, of a bright red color and translucent. Streak orange-yellow. $\mathrm{H} .=2 \cdot 5-3 . \quad$ G. $=5 \cdot 9-6 \cdot 1$.

Composition. $\mathrm{Pb} \mathrm{O}_{4} \mathrm{Cr}=$ Chromium trioxide $31 \cdot 1$, lead oxide $68 \cdot 9$. Blackens and fuses, and forms a shining slag containing globules of lead.

Obs. Occurs in gneiss at Beresof in Siberia, and also in Brazil. This is the chrome yellow of the painters.

Phrenicochroite (or Melanochroite) is another lead chromate, contain. ing 23.0 of chromium trioxide, and having a dark red color; streak brick-red. Crystals usually tabular and reticulately arranged. G. $=5 \cdot \%$. From Siberia.

Vauquelinitc. A lead and copper chromate, of a very dark green or pearly black color, occurring asually in minute irregularly aggregated crystals; also reniform and massive. $\mathrm{H} .=2 \cdot 5-3$. G. $=5 \cdot 5-5 \cdot 8$. From Siberia and Brazil ; also at the lead mino near Sing Sing, in mammillary concretions.

Stolzite, or lead tungstatc. In square octahedrons or prisms. Color green, gray, brown, or red. Lustro resinous. H. $=2 \cdot 5-3 . \quad$ G. $=7 \cdot 0-$ 81 . Contains 51 of tungstic acid and 49 of lead.

Wulfenite, or lead molybdate. In dull-yellow octahedral crystals, and also massive. Lustre resinous. Contains molybdenum trioxide $34 \cdot 25$, protoxide $64 \cdot 42$. From Bleiberg and elsewhere in Carinthia; also Hungary. It has been found in small quantities in the Southampton lead mine, Mass., and in fine crystals, at Phonixville, Penn.
Lead Sulphato-carbunctes. There are two whitish or grayish ores of this composition called Lanarkite and Leadhillite. The former contains 71 per cent. of carbonate of lead; the latter, 47.

## Pyromorphite.-Lead Phosphate.

Hexagonal. In hexagonal prisms ; often in crusts made of crystals. Also in globules or reniform, with a radiated structure.

Color bright green to brown ; sometimes finc orange-ycllow, owing to an intermixture with chromate of lead. Streak white or nearly so. Lustre more or less resinous.
 Nearly transparent to subtranslucent. Brittle. H. $=3 \cdot 5-4$. G. $=6 \cdot 5-7 \cdot 1$.

Composition. $\mathrm{Pb}_{3} \mathrm{O}_{8} \mathrm{P}_{\mathrm{g}}+\frac{1}{3} \mathrm{~Pb} \mathrm{Cl}_{2}=\mathrm{Ph}_{2}-$ phorus pentoxide $15 \cdot \% 1$, lead oxide $82 \cdot 2 \%$, chlorine $2 \cdot 62$ $=100 \cdot 60$. B. B. fuses easily in the forceps, coloring the flame bluish green. On charcoal fuses, and on cooling, the globule becomes angular ; the coal is coated white from the chloride, and nearer the assay, yellow from lead oxide. Soluble in nitric acid.

Diff. Has some resemblance to beryl and apatite ; but is quite different in its action before the blowpipe, and much higher in specific gravity.

Obs. Leadhills, Wanlockhead, and other lead mines of Curope are forcign localities. In the United States, very handsome crystallized specimens occur at King's Mine, in Davidson County, N. C.; other localities are tho Perkiomen and Phenixville mines, Pa. ; the Lubec lead mines, Me.; Lenox, N. Y. ; formerly, a mile south of Sing Sing, N. Y.; and the Southampton lead mine, Mass.
The name pyromorphite is from the Greck pur, fire, and morphe, form, alluding to its crystallizing on cooling from fusion before the blowpipe.
Mimetite. A lead arsenate, resembling pyromorphite in crystallization, but giving a garlic odor on charcoal before the blowpipe. Color pale yellow, passing into brown. H. $=2 \cdot 75-3 \cdot 5$. G. $=6 \cdot 41$. Composition, $\mathrm{Pb}_{5} \mathrm{O}_{\mathrm{F}} \mathrm{As}_{3}+1 ; \mathrm{Pb} \mathrm{Cl}_{2}=$ Arsenic pentoxide $23 \%$, lead oxide 74.96, chlorine $2 \cdot 30=100 \cdot 55$. From Coruwall and elsewhere; Phœnixville, Pa.

Hedyphane is a variety of mimetite containing much lime. It occurs amorphous, of a whitish color, and adamantine lustre. H. $=$ $3 \cdot 5-4$. G. $=5 \cdot 4-5 \cdot 5$.

Karyinite. A lead arsenate containing manganese and calcium, from Norway.

Ecdemite. A lead chloro-arsenate.
Vanadinite. A lead vanadate occurring in hexagonal prisms like pyromorphite, and also in implanted globules. Color yellow to reddish brown. H. $=2.75-3$. G. $=6 \% 6-\% \cdot 3$. From Mexico; also from Wanlockhead in Dumfriesshire.

Monimolite. A yellow lead antimonate.
Nadorite. A vellow lead chlor-antimonate
Bindhcimite. A hydrous lead antimonate.

## Cerussite.-White Lead Ore. Lead Carbonate.

Trimetric. In modified right rhombic prisms, and often in compound crystals, two or three crossing one another as

in fig. 7. $I \wedge I=117^{\circ} 13^{\prime}$. Also in six-sided prisms like aragonite. Also massive; rarely fibrous.

Color white, grayish, light or dark. Lustre adamantine. Brittle. H. $=3-3 \cdot 5 . \quad \mathrm{G} .=6 \cdot 46-6 \cdot 48$.

Composition. $\mathrm{Pb} \mathrm{O}_{3} \mathrm{C}=$ Carbon dioxide 16.5 , lead oxide $83 \cdot 5=100$. B. B. decrepitates, fuses, and with care on charcoal affords a globule of lead. Effervesces in dilute nitric acid.

Diff. Like anglesite, distinguished from most of the species it resembles by its specific gravity and yielding lead when heated. From anglesite it differs in giving lead alone before the blowpipe, as well as by its solution and effervescence with nitric acid, and its less glassy lustre.

Obs. Associated usually with galena. Leadhills, Wanlockhead, and Cornwall have afforded splendid crystallizations; also Linares, in Spain, and other lead mines on the continent of Europe.

In the United States, handsome specimens are obtained at Austin's Mines, Wythe County, Virginia, and at King's Mine, in Davidson's County, North Carolina; at the latter placo it has been worked for lead, and it is associated with native silver and pyromorphite. Perkiomen and Phœenixville, Penn., afford grood crystals. It, occurs also at "Vallée's Diggings," Jefferson County, Missouri, and other mines, in that State; at Brigham's Mine, near the Blue Mounds, Wisconsin, partly in stalactites; at " Deep Diggings," in crystals; and at other places, both massive and in fine crystallizations.

When abundant, this ore is wrought for lead. Large quantities oceur about the mines of the Mississippi Valley. It was formerly buried up in the rubbish as useless, but it has since been collected and smelted. It is an exceedingly rich ore, affording in the pure state 75 per cent. of lead.

Carbonate of lead is the "white lead" of commerce, so extensively used as a paint. The material for this purpose is, however, artificially made.
Phosgenite or Cornenus Lead. A chloro-carbonate of lead, occurring in whitish adamantine crystals. $\mathrm{H}=2 \cdot 75-4$. $\mathrm{G} .=6-631$. Composition, $\mathrm{PbO}_{3} \mathrm{C}+\mathrm{PbCl}_{3}$. From Derbyshire and Gernany.
Hydrocerussite. Hydrous lead carbonate. From Sweden.
Ganomalite is a white leed-mangancse silicate, affording $34 \cdot 59$ per cent. of lead oxide. From Sweden. Hyalotecite is a lead-barium-lime silicate. Both are from Longban, Sweden.

General Remarks.-The lead of commerce is derived almost wholly from the sulphide of lead or galenite, the localities of which have already been mentioned. In some mining regions, the carbonate and sulphate are abundant.

The lead mines of the Central United States afforded in 1826, 1,770 tons ; in 1842, 17,340 tons; and of late years, 12,000 to 15,000 tons.

Nevada produced 10,000 tons in 1870, and 50,000 in 1875. According to Phillips, England produced in 1872, 60,450 tons; Prussia, in 1871, 49,500 tons ; Spain, in 1873, 102,600 tons; France, 2,500 tons ; Italy, 15,500 tons ; Austria, 10,000 tons.

## ZINC.

Zinc occurs in combination with sulphur and oxygen; and also in the condition of silicate, carbonate, sulphate, and arsenate. It is also a constituent of one variety of the species spinel. The chief sources of the metal are smithsonite or the carbonate; willemite and calamine, or silicates; zincite, or the oxide; sphalerite (blende), or the sulphide ; and franklinite.

> Sphalerite.-Blende. Zinc Sulphide.

Isometric. In dodecahedrons, octahedrons, and other allied forms, with a perfect dodecahedral cleavage. Also maswive ;

sometimes fibrous. Color wax-yellow, brownish-yellow, to black, sometimes green, red and white; streak white, to reddish brown. Lustre resinous or waxy, and brilliant on a cleavage face ; sometimes submetallic. Transparent to subtranslucent. Brittle. II. $=3 \cdot 5-4 . \quad$ C. $=3 \cdot 9-4 \%$. Some specimens become electric with friction, and give off a yellow light when rubbed with a feather.

Composition. $\mathrm{ZnS}=$ Sulphur 33, zinc $67=100$. Contains frequently a portion of iron sulphide when dark colored; often also 1 or 2 per cent. of cadmium sulphide, especially the red variety. Nearly infusible alone and with borax. Dissolves in nitric acid, emitting sulphuretted hydrogen. Strongly heated on charcoal yields fumes of zinc.

Diff. This ore is characterized by its waxy lustre, perfect cleavage, and its being nearly infusible. Some dark varietics look a little like tin ore, but their cleavage and inferior hardness distinguish them; and some clear red crystals,
which resemble garnet, are distinguished by the same chararacters and also by their very difficult fusibility.

Obs. Occurs in rocks of all ages, and is associated generally with ores of lead ; often also with copper, iron, tin, and silver ores. The lead mines of Missouri and Wisconsin afford this ore abundantly. Other localities are in Maine, at Lubec, Bingham, Dexter, Parsonsfield; in New Hampshire, at Eaton, Warren, Haverhill, Shelburne ; in Vermont, at Hatfield; in Connecticut, in Brookfield, Berlin, Roxbury, and Monroe; in New York, at Ancram lead mine, the Wurtzboro' lead vein, at Lockport, Root, 2 miles southeast of Spraker's Basin, in Fowler, at Clinton ; at Franklin, N. J., colorless (Cleiophane) ; in Pennsylvania, at the Perkiomen lead mine ; in Virginia, at Austin's lead mine. Wythe County; in Tennessee, near Powell's River, and at Haysboro'; at Prince's Mine, Spar Island, Lake Superior, with ores of silver; in Beauce Co., Canada, where it is slightly auriferous.

This ore is the Black-jack of miners.
Blende is a useful ore of zinc, though more difficult of reduction than calamine. By its decomposition (like that of pyrite), it affords sulphate of zine or white vitriol.

Wurtzite is zinc sulphide in hexagonal crystals from Bolivia. Huas. colite and Youngite are zinc-lead sulphides.

> Zincite.-Red Zinc Ore. Red Zinc Oxide.

Hexagonal. Usually in foliated masses, or in disseminated grains ; cleavage eminent, nearly like that of mica; but the laminæ brittle, and not so easily separable.

Color deep or bright red; streak orange-yellow. Lustre brilliant, subadamantinc. Translucent or subtranslucent. $\mathrm{H} .=4-4 \cdot 5 . \quad$ G. $=5 \cdot 4-5 \%$. Thin scales by transmitted light deep yellow.

Composition. $\mathrm{Zn} \mathrm{O}=$ Oxygen $19 \%$, zinc $80 \cdot 3=100$. B.B. infusible alone, but yields a yellow transparent glass with borax ; on charcoal, a coating of zinc oxide. Dissolves in nitric acid without effervescence.

Diff. Resembles red stilbite, but distinguished by its infusibility and also by its mineral associations.

Obs. Occurs with franklinite at Mine Lill and Sterling Hill, Sussex County, N. J.

A good ore of zinc, and easily reduced.
Voltzite. A componnd of sulphur, oxygen and zinc, $4 \mathrm{ZnS}+\mathrm{ZnO}$. Occurs in implanted globules of a dirty rose-red color, with a pearly lustre on a cleavage surface. From France, and near Joachimstahl.

## Goslarite.-Sulphate of Zinc. White Vitriol.

Trimetric. Cleavage perfect in one direction. $I \wedge I=$ $90^{\circ} 42^{\prime}$.

Color white. Lustre vitreous. Easily soluble ; taste astringent, metallic, and nauseous. Brittle. $11 .=2 \boldsymbol{2} \cdot 5 . \quad$ (.$=$ 1-9-2-1.

Composition. $\mathrm{ZnO} \mathrm{O}_{4} \mathrm{~S}+7$ aq. $=$ Zinc oxide $28 \cdot 2$, sulphur trioxide $27 \cdot 9$, water $43 \cdot 9=100$. B. B. gives off fumes of zinc on charcoal, which cover the coal.

Obs. Results from the decomposition of blende. Occurs in the Hartz, in Hungary, in Sweden, and at Holywell in Wales.

Sulphate of zinc is extensively employed in medicine and dreing. For these purposes it is prepared to a large extent from blende by decomposition, though this affords, owing to its impurities, an impure sulphate. It is also obtained by direct combination of zinc with sulphuric acid.

White Vitriol, as the term is used in the arts, is one form of sulphate of zinc, made by melting the crystallized sulphate, and agitating till it cools and presents an appearance like loaf sugar.

Köttigitc. A hydrous zinc-cobalt arsenate of reddish color (owing to presence of cobalt) from Schneeberg

Adamite. A hydrous zinc-arsenate of honey-yellow to violet color, from Chili.

> Smithsonite.-Carbonate of Zinc.

Rhombohedral. $R \wedge R=107^{\circ} 40^{\prime}$. Cleavage $R$ perfect. Massive or incrusting ; reniform and stalactitic.

Color impure white, sometimes green or brown ; streak uncolored. Lustre vitreous or pearly. Subtransparent to translucent. Brittle. H. $=5$. G. $=4 \cdot 3-4 \cdot 45$.

Composition. $\mathrm{ZnO} \mathrm{O}_{3} \mathrm{C}=$ Carbon dioxide $35 \cdot 2$, zine oxide 64.8 (four-fifths of which is pure zinc $)=100$. Often contains some cadmium. B.B. infusible alone, but carbonic acid and oxide of zinc are finally vaporized. Effervesces in nitric acid. Negatively electric by friction.

Diff. The effervescence with acids distinguishes this mineral from the following species; and the hardness, difficult fusibility, and the zinc fumes before the blowpipe, from the carbonate of lead or other carbonates. Besides, the crystals over a drusy surface terminate usually in sharp three-sided pyramids.

Obs. Occurs commonly with galena or hlende, and usually in calcareous rocks. Found in Siberia, Hungary, Silesia; at Bleiberg in Carinthia; near Aix-la-Chapelle in the Lower Rhine, and largely in Derbyshire and elsewhere in England. In the United States, it is abundant at Vallé's Diggings in Missouri, and at other lead "diggings" in Iowa and Wisconsin ; also in Claiborne County, Tenn. Sparingly also at Hamburg, near the Franklin Furnace, N. J.; at the Perkiomen lead mine, Pa., and at a lead mine in Lancaster County.

Hydrozincite is a hydrous zinc carbonate, $\mathrm{ZnO}_{3} \mathrm{C}+2 \mathrm{Zn} \mathrm{O}_{2} \mathrm{H}$, of a whitish color, with G. $=3: 58-3 \cdot 8$.

Aurichalcite is a hydrous carbonate of zinc and copper, occurring in drusy incrustations of acicular crystals, having a pale verdigris-green color. From Siberia, Hungary, England, and Lancaster, Pa.

Buratite is a lime aurichalcite.

> Willemite.-Zinc Silicate. Troostite.

Rhombohedral. $R \wedge R=116^{\circ} 1^{\prime}$. In hexagonal prisms, and also massive.

Color whitish, greenish yellow, apple-green, flesh-red, yellowish brown. Streak uncolored. Transparent to oparue. Brittle. II. $=5 \cdot 5 . \quad$ G. $=3 \cdot 89-4 \cdot 18$.

Composition. $\mathrm{Zn} \mathrm{O} \mathrm{O}_{3} \mathrm{Si}=$ Silica $27 \cdot 1$, zinc oxide $72 \cdot 9=$ 100. 13.B. fuses with difficulty to a white enamel ; on charcoal, and most casily on adding soda, yields a coating which is yellow while hot, and white on cooling, and which, moistened with cobalt solution and treated in O.F., is colored bright green. Gelatinizes with hydrochloric acid.

Obs. From Moresnet, between Liege and Aix-la-Chapelle; Raibel in Carinthia; Greenland. Abundant at both Franklin and Sterling, mixed with zincite, and used as an ore of zinc ; also in prismatic crystals that occasionally are six inches long.

Calamine.-Hydrous Zinc Silicate. Galmei.
Trimetric. In rhombic prisms, the opposite extremities with unlike planes. $I \wedge I=104^{\circ} 13$. Clearage perfect parallel to $I$. Also massive and incrusting, mammillated or stalactitic.

Color whitish or white, sometimes bluish, greenish, or brownish. Streak uncolored. Transparent to translucent. Lustre vitreous or subpearly. Brittle. H. $=4 \cdot 5-5$. G. $=$ $3 \cdot 16-3 \cdot 9 . \quad$ Pyro-electric.

Composition. $\mathrm{Zn}_{2} \mathrm{O}, \mathrm{Si}+\mathrm{aq} .=$ Silica $25 \cdot 0$, zinc oxide 675 , water $7 \cdot 5=100$.
B.B. alone it is almost infusible. Forms a cloar glass with borax. In heated sulphuric acid it dissolves, and the solution gelatimizes on cooling.
Diff. Differs from calcite and aragonite by its action with acids; from a salt of lead, or any zeolite, by its infusibility ; from chalcedony by its inferior hardness, and its gelatinizing with heated sulphuric acid; and from smithsonite by not effervescing with acids, and by the rectangular aspect of its crystals over a drusy surface.

Obs. Occurs with calamine. In the United States it is found at Vallée's Diggings, Mo.; at the Perkiomen and Phoenixville lead mines; on the Susquehanna, opposite Selinsgrore; at Friedensville in Sancon Valley, two miles from Bethlehem, Pa., with massive blende. Abundantly at Austin's Mines, Wythe County, Va. Valuable as an ore of zinc.

Hopeite is a rare mineral occurring in grayish-white crystals or mas. sive, with calamine, and supposed to be a hydrous zinc-phosphate.

Franklinite, an ore of iron, manganese and zinc, is described under iron, on page 179.

General Remarks.-The metal zinc (spelter of commerce) is supposed to have been unknown in the metallic state to the Greeks and Romans. It has been long worked in China, and was formerly imported in large quantities by the East lndia Company.

The principal mining regions of zinc in the world are in Upper Silesia, at Tarnowitz and elsewhere ; in Poland ; in Carinthia, at Raibel and Bleiberg; in Netherlands at Limberg; at Altenberg, near Aix-laChapelle in the Prussian province of the Lower Rhine; in England, in Derbyshire, Alstonmoor, Mendip Hills, etc.; in the Altai in Russia; besides others in China, of which little is known. In the United States, smithsonite and calamine occur with the lead of the West in large quantities. They were formerly considered worthless and thrown aside, under the name of "dry bone." In Tennessee, Claiborne County, there are workable mines of the same ores. Calamine occurs at Friedensville, Pennsylvania, along with massive blende: the bed has been, but is not now worked. The zincite, willemite, and franklinite of Franklin, New Jersey, are together worked as a zinc ore, and both zinc and zinc oxide are produced. Blende is sufficiently abunciant to be worked at the Wurtzboro' lead mine, Sullivan County, New York; at Eaton and Warren, in New Hampshire ; at Lubec, in Maine; at Austin's Mine, Wythe Countr, Virginia, and at some of the Missouri lead mines.
The amount of zinc produced in 1872, in Europe, was about 45,745 tons for Belgiam ; 55, 744 for Germany ; 8,000 for Austria; 15,000 for Great Britain ; 4,400 for France; 4,400 for Spain : making the total amount 128,289 tons. In the United States the amount of zinc made in 1875 was about 15,000 tons ; of zinc oxide, 8,500 tons.

Zinc is a brittle metal, but admits of being rolled into sheets when heated to about $212^{\circ} \mathrm{F}$. In sheets it is extensively used for roofing and other purposes, it being of more difficult corrosion, much harder, and also very much lighter than lead. It is also employed largely for coating (that is, making what is called galvanized) iron. Its alloys with copper (page 144) are of great importance.

The white oxide of zinc is much used for white paint, in place of white lead; and also in making a glass for optical purposes.

An impure oxide of zinc, called cadmia, often collects in large quantities in the flues of iron and other furnaces, derived from ores of zinc mixed with the ores undergoing reduction. A mass weighing 600 pounds was taken from a furnase at Bennington, Vt. It has been observed in the Salisbury iron furnace, and at Ancram, in New Jersey, where it was formerly called Ancramite.

## CADMIUM.

There is but a single known ore of this rare metal. It is a sulphide, and is called Greenockite. It occurs in hexagonal prisms, with dissimilar pyramidal termination, of a light yellow color, high lustre, and nearly transparent. II. $=3-$ $3 \cdot$. G. $=4-8-5$. From Bishopton, Scotland.

Cadmium is often associated with zinc in sphalerite and calamine. The cadmiferous sphalerite is called Przibramite.
The metal cadmium is white like tin, and is so soft that it leaves a trace upon paper. It fuses at $442^{\circ} \mathrm{F}$. It was discovered by Stromeyer in 1818.

## TIN.

Tin has been reported as occurring native in the gold washings of the Ural, and in Bolivia. There are two ores, a sulphide and an oxide. It also occurs in some ores of columbium, tantalum, and tungsten.

Stannite.--Tin Pyrites, Sulphuret of Tin. Tin Sulphide.
Commonly massive, or in grains. Color steel-gray to ironblack ; streak blackish. Brittle. H. $=4$. G. $=4 \cdot 3-4 \cdot 6$.

Composition. Sulphur 30, tin 27, copper 30, iron $13=100$.
Obs. From Cornwall, where it is often called bell-metal ore, from its frequent bronze appearance ; also from Ireland and the Erzgebirge.

## Cassiterite. -Tin Ore. Tin Oxide.

Dimetric. In square prisms and octahedrons; often com-
1.
 pounded. $1 \wedge 1=121^{\circ} 40^{\prime} ; 1 i$ $\wedge \mathrm{l} i$ (over the summit) $11 z^{\circ}$ $10^{\prime}$, (over a terminal edge) $133^{\circ} 31^{\prime}$. Cleavage indistinct. Also massive, and in grains.

Color brown or black, with a high adamantine lustre when in crystals. Streak pale gray to brownish. Nearly trans-
parent to opaque. $I I=6-\% \quad$ G. $=6 \cdot 4-7 \cdot 1$.
Composition. Sn $\mathrm{O}_{2}=0 \times y$ gen $21 \cdot 33$, tin 78.67 ; often contains a little iron, and sometimes tantalum.
B.B. alone infusible. On charcoal with soda, affords a globule of tin.

Stream tin is the gravel-like ore found in debris in low grounds. Wood tin occurs in botryoidal and reniform shapes with a concentric and radiated structure ; and toads-eye tin is the same on a small scalc.

Diff. Tin ore has some resemblance to a dark garnet, to black zinc blende, and to some varieties of tourmaline. It is distinguished by its infusibility, and its yielding tin bofore the blowpipe on charcoal with soda. It differs from blende also in its superior hardness.

Obs. Tin ore occurs in veins in the crystalline rocks, granite, gneiss, and mica slate, associated often with wolfram, copper and iron pyrites, topaz, tourmaline, mica or talc, and albite. Cornwall is one of its most productive localities. It is also worked in Saxony, at Altenberg, Geyer, Ehrenfriedersdorf and Zinnwald; in Austria, at Schlackenwald and other places ; in Malacca, Pegu, China, and especially tho Island of Banca in the East Indies; in Queensland and Northern New South Wales, Australia, in large quantities; in Greenland. It occurs also in Galicia, Spain; at Dalecarlia in Sweden; in Russia; in Mexico at Durango; and Bolivia. In the United States it has been found sparingly at Chesterfield and Goshen, Mass ; in some of the Virginia gold mines ; in Lyme and Jackson, N. H. ; and in the Temescal Range, California.

General Remarks.-The principal tin mines now worked, are those of Cornwall, Banca, Malacca, and Australia.

The Cornwall mines were worked long before the Christian era.

Herodotus, 450 years before Christ, is believed to allude to the tin islands of Britain under the cabalistic name Cassiterides, derived from the Greek kassiteros, signifying tin. The Phonicians are allowed to have traded with Cornubia (as Cornwall was called, it is supposed from the horn-like shape of this extremity of England). The Greeks residing at Marseilles were the next to visit Cornwall, or the isles adjacent, to purchase tin; and after them came the Romans, whose merchants were long foiled in their attempts to discover the tin market of their predecessors.

Camden says: "It is plain that the ancient Britons dealt in tin mines from the testimony of Diodoras Siculus, who lived in the reign of Augustus, and Timaus, the historian in Pliny, who tells us that the Britons fetched tin out of the Isle of Icta (the Isle of Wight), in their little wicker boats covered with leather. The import of the passage in Diodorus is that the Britons who lived in those parts dug tin out of a rocky sort of ground, and carried it in carts at low water to certain neighboring islands; and that from thence the merchants first transported it to Gaul, and afterwards on horseback in thirty days to the springs of Eridanus, or the city of Narbona, as to a common mart. Ethicus too, another ancient writer, intimates the same thing, and adds that he had himself given directions to the workmen." In the opinion of the learned author of the Britannica here quoted, and others who have followed him, the Saxons seem not to have meddled with the mines, or, according to tradition, to have employed the Saracens; for the inhabitants of Cornwall to this day call a mine that is given over working Attal-Sarasin, that is, the leavings of the Saracens.

The Cornwall veins, or lodes, mostly run east and west, with a dip -lade, in the provincial dialect-varying from north to south; yet they are very irregular, sometimes crossing each other, and sometimes a promising vein abruptly narrows or disappears; or again they spread out into a kind of bed or floor. The veins are considered worth working when but three inches wide. The gangue is mostly quartz, with some chlorite. Much of the tin is also obtained from beds of loose stones or gravel (called 8 ludes), and courses of such gravel or tin debris aro called streams, whence the name strcane tin.
The Australian mines are mainly in the New England district of Northern New South Wales, and the adjoining part of Queensland, and a large part of the ore goes north through Queensland. The value of the tin exported in 1875 from Queensland was $£ 88,224$, and from Now South Wales (Ann. Rep. Dept. of N. S. W. Mines, 1876). £561,311, corresponding to 6,058 tons of tin in ingots, besides 2,022 tons of ore. The value of all the tin raised in N. S. Wales, prior to 1875 is $£ 866,461$. Beachwood, Victoria, also affords a little tin.
The annual production of tin in $18 i 1$ in Great Britain was 11,320 tons, and in Banca and Malacca, 7,500.

Tin is used in castings, and also for coating other metals, especially iron and copper. Copper vessels thus coated were in use among the Romans, though not common. Pliny says that the tinned articles could scarcely be distinguished from silver, and his use of the words incoquere and incoctilia seems to imply, as a writer states, that the process was the same as for the iron wares of the present day, by immersing the vesscls in melted tin. Its alloys with copper are mentioned on page 144.

Tin is also used extensively as tinfoil ; but most tinfoil consists beneath the surface of lead, and is made by rolling out plates of lead costed with tin. With quicksilver it is used to cover glass in the manufacture of mirrors. Tin oxide (dioxide), obtained by chemical processes, is employed, on account of its hardness, in making a paste for sharpening fine cutting instruments, and also to some extent in the preparation of enamels. The chlorides of tin are important in the precipitation of many colors as lakes, and in fixing and changing colors in dyeing and calico-printing. The bisulphide has a golden lastre, and was termed aurum musivum, or mosaic gold, by the alchemists. It is much used for ornamental painting, for paper-hangings and other purposes, under the name of bronze powder.

## TITANIUM.

Titanium occurs in nature combined with oxygen, forming titanium dioxide or titanic acid, and also in oxygen combinations with iron and calcium, and in some silicates. It has not been met with native.
The ores are infusible alone before the blowpipe, or nearly so. Their specific gravity is botween $3 \cdot 0$ and $4 \cdot 5$.

## Rutile.

Dimetric. In prisms of four, eight, or more sides, with pyramidal terminations, and often bent as in
 the figure; $1 \wedge 1=123^{\circ} 7 \frac{1}{2}^{\prime}$. Crystals oflen acicular, and penetrating quartz. Sometimes massive. Cleavage lateral, somewhat distinct.
Color reddish-brown to nearly red ; streak very pale brown. Lustre submetallic-adamantine. Transparent to opaque. Brittle. H. $=6-6 \cdot 5 . \quad$ Q. $=4 \cdot 15-4 \cdot 25$.

Composition. Ti $\mathrm{O}_{2}=$ Oxygen 39, titanium $61=100$. Sometimes contains iron, and has nearly a black color ; this variety is called Nigrine. B.B. alone unaltered; with salt of phosphorus a colorless bead, which in the reducing flame becomes violet on cooling.
Diff: The peculiar subdamantine lustre of rutile, and brownish-red color, much lighter red in splinters, are striking characters. It differs from tourmaline, idocrase, and augite, by being unaltered when heated alone before the blowpipe; and from tin ore, in not affording tin with soda; from sphene in its crystals.

Obs. Occurs imbedded in granite, gneiss, mica schist syenyte, and in granular limestone. Sometimes associated with hematite, as at the Grisons. Yricix in France, Castile, Brazil, and Arendal in Norway, are some of the foreign localities.

In the United States, it occurs in crystals in Maine, at Warren ; in New Hampshire, at Lyme and Hanover ; in Massachusetts, at Barre, Windsor, Shelburne, Leyden, Conway; in Connecticut, at Monroe and Huntington ; in New York, near Edenville, Warwick, Amity, at Kingsbridge, and in Essex County at Gouverncur ; in Pennsylvania, in Chester County; in the District of Columbia, at Georgetown; in North Carolina, in Buncombe County ; in Georgia, in Lincoln and Habersham counties ; at Magnet Cove in Arkansas.

The specimens of limpid quartz, penetrated by long acicular crystals, are often very handsome when polished. A remarkable specimen of this kind was obtained in Northern Vcrmont, and less handsome ones are not uncommon; they are found in North Carolina. Polished stones of this kind are called fleches d'amour (love's arrows) by the French.

This ore is cmployed in painting on porcelain, and quite largely for giving the requisite shade of color and enamel appearance to artificial teeth.

Octahedrite (Anatase) ; Brookitc. These species have the same composition as rutile. Octahedrite occurs in slender nearly transparent octahedrons, of a brown color. $1 \wedge 1=97^{\circ} 51^{\prime} . \quad H .=5{ }^{\circ}-6 . \quad G .=3 \cdot 8-$ 3.95. From Dauphiny, the Tyrol, and Brazil ; at Smithfield, R. I.

Brookite is met with in thin hair-brown flat trimetric crystals, attached by one edge. Also in thick imn-black crystals, as in the variety called Arkansite. H. $=5.5-6$. From Dauphiny; Snowdon in Wales; Ellenville, Ulster County, N. Y. ; Paris, Maine ; gold washings of North Carolina; Magnet Cove, Arkansas (Arkansite).
Perofskite. In cubic crystals, of yellow, brown, and black colors ; chemical formula ( $\mathrm{Ti}, \mathrm{Ca})_{3} \mathrm{O}_{3}$. From the Urals, the Tyrol, and Magnet Cove, Arkansas.

Besides the ores here described, titanium is an essential constituent also of ilmenite (titanic iron), and of the silicates titanite or sphene (p. 290), Keilhauite (p. 291), wcarwickite; and occurs also in the zirconia and yttria ores aschynite, arsteditc, and polymignite, and in some other raro species; sometimes in pyrochlore.

## COBALT. NICLEL.

Cobalt has not been found native. The ores of cobalt are sulphides, arsonides, arsono-sulphides, an oxide, a carbonate, a phosphate, and an arsenate; and nickel is often
associated with coloalt in the sulphides and arsenides. The ores having a metallic lustre vary in specific gravity from $6 \cdot 2$ to $7 \cdot 2$; and the color is nearly tin-white or pale steel_ gray, inclined to copper-red. The ores without a metallic lustre have a clear red or reddish color, and specific gravity of nearly 3. Cobalt is often present also in arsenopyrite (or mispickel), and sometimes in pyrite.
The ores of nickel are sulphides, arsenides, arseno-sulphides, and antimono-sulphides, a sulphate, carbonate, silicates, arsenate; and the metal is a constituent of several cobalt ores, and also often of pyrrhotite (magnetic pyrites). Specific gravity between 3 and 8 ; hardness of one 3 , but mostly between 5 and 6 . Those of metallic lustre resemble some cobalt ores; but they do not give a deep bluc color with borax.

Linnæite.-Cobalt Sulphide. Cobalt and Nickel Sulphide.
Isometric. In octahedrons and cubo-octahedrons; also massive. Color pale steel-gray, tarnishing copper red. Streak blackish gray. $\mathrm{H} .=5 \%$. ( $\mathrm{F} .=4 \cdot 8-5$.

Composition. $\mathrm{Co}_{3} \mathrm{~S}_{4}=$ Sulphur $42 \cdot 0$, cobalt $5 \cdot 80=100$; but with part of the cobalt replaced by nickel ; copper sometimes present. Siegenite is a variety containing 30 to 40 per cent. of nickel. B.B. on charcoal yields sulphurous odor and a magnetic globule; often also arsenical fumes.

Obs. From Sweden, Prussia; Mine la Motte in Missouri (Siegenite); Mineral Hill in Maryland. Sometimes called cobalt pyrites.

Millerite.-Nickel Sulphide. Capillary Pyrites.
Rhombohedral. Usually in capillary or needle-like crystallizations; sometimes like wool. Also in columnar crusts and radiated. Color brass-yellow, inclining to bronze-yellow, with often a gray iridescent tarnish. Streak bright. Brittle. $\mathrm{H} .=3-3 \cdot 5 . \quad G .=4 \cdot 6-5 \cdot 65$.

Composition. Ni $\mathrm{S}=$ Sulphur $35 \cdot 6$, nickel $64 \cdot 4=100$. In the open tube sulphurous fumes. B.B. on charcoal fuses to a globule; and after roasting, gives, with borax and salt of phosphorus, a violet bead in O.F., which in R.F. becomes gray from reduced metallic nickel.

Obs. From Joachimstahl, Przibram, Riechelsdorf ; Saxony; Cornwall ; at the Sterling Mine, Antwerp, N. Y.; at the Gap Mine, Lancaster Co., Pa.; at St. Louis, Mo., in capillary forms, and sometimes wool-like, in cavities in magnesian limestone. A valuable ore of nickel.
Beyrichite has the formula $\mathrm{Ni}_{5} \mathrm{~S}_{7}$.

## Smaltite.-Cobalt Glance. Chloanthite.

Isometric. Occurs in octahedrons, cubes, and dodecahedrons, and other forms. See figs. 1, 2, 3, page 17, and 17, 27, page 20. Clearage octahedral, somewhat distinct. Also reticulated; often massive.

Color tin-white, sometimes inclining to steel-gray. Streak grayish black. Brittle. Fracture granular and uneven. $\mathrm{H} .=5 \cdot 5-6 . \quad \mathrm{G} .=6 \cdot 4-7 \cdot 2$.

Composition. (Co, Ni) $\mathrm{As}_{2}$; the ore being cither a cobalt arsenide, or cobalt-nickel arsenide; and graduating into the nickel arsenide called Chloanthite. The cobalt in the ore may constitute 23.5 per cent. ; but it may be wholly absent as in the chloanthite. In addition, iron often replaces part of the other metals, as in the variety Safflorite.

In the closed tube gives a sublimate of metallic arsenic; in the open tube a white sublimate of arsenous oxide, and sometimes traces of sulphurous acid. B.B. on charcoal, affords an arsenical odor, fuses to a globule which gives reaction for iron, cobalt, and nickel.

Diff. Arsenopyrite (mispickel) has the white color of smaltite, but it yields sulphur as well as arsenic, and in a closed tube affords arsenic sulphide, orpiment and realgar.

Obs. Usually in veins with ores of cobalt, silver, and copper. Occurs in Saxony, especially at Schneeberg; also in Bohemia, Messia, and Cornwall.

In the United States it is found in gueiss with copper nickel (niccolite), at Chatham, Conn.

## Cobaltite.

Isometric. Crystals like those of pyrite, but silver-white in color with a tinge of red, or inclined to steel-gray. Streak grayish black. Brittle. H. $=5 \cdot 5$. G. $=6 \cdot 63$.

Composition. $\mathrm{CoS}_{2}+\mathrm{Co} \mathrm{As} s_{2}=\mathrm{Co} \mathrm{AsS}=$ Arsenic $45^{\circ} 2$, sulphur $19 \cdot 3$, cobalt $35 \cdot 5=100$, but often with much iron and occasionally a little copper. Unaltered in the closed
tube; but in the open tube, yields sulphurous fumes and a white sublimate of arsenous oxide. B.B. on charcoal yields sulphur and arsenic and a magnetic globule; with borax a cobalt-blue globule.
Diff. Unlike smaltite affords sulphur, and has a reddish tinge in its white color.

Obs. From Sweden, Norway, Siberia, and Cornwall. Most abundant in the mines of Wehna in Sweden, first opened in 1809.

## Niccolite.-Copper Nickel. Arsenical Nickel.

Hexagonal. Usually massive. Color pale copper-red. Streak pale brownish-red. Lustre metallic. Brittle. H. $=$ $5-5 \cdot 5$. G. $=7 \cdot 3-7 \cdot \%$.

Composition. Ni As=Nickel 44, and arsenic 56 ; sometimes part of the arsenic is replaced by antimony. Gives off arsenical (alliaceous) fumes before the blowpipe, and fuses to a pale globule, which darkens on exposure. Assumes a green coating in nitric acid, and is dissolved in aqua-regia.
Diff. Distinguished from pyrite and linnæite by its pale reddish shade of color, and also its arsenical fumes, and from much of the latter by not giving a blue color with borax. None of the ores of silver with a metallic lustre have a pale color, excepting native silver itself.

Obs. Accompanies cobalt, silver, and copper ores in the mines of Saxony, and other parts of Europe ; also sparingly in Cornwall.
It is found at Chatham, Conn., in gneiss, associated with white nickel or cloanthite.

Skutterudite. A cobalt arsenide of the formula $\mathrm{CoAs}_{3}$, from Skutterud, Norway.

Breithauptite or Antimonial Nickel. Ni $\mathrm{Sb}=$ Antimony $67 \cdot 8$, nickel $39 \cdot 2=100$. It has a pale copper-red color, inclining to violet. H. $=55$ -6 . G. $=7.54$. Crystals hexagonal. From Andreasberg.

Gersdorfite. A nickel arsenosulphide; $\mathrm{NiS}_{2}+\mathrm{NiAs}_{2}=\mathrm{Ni} A s S=$ Arsenic 45.5, sulphur 19.4, nickel $35 \cdot 1$, bat varying much in composition. Color sulphur-white to steel-gray. $\mathrm{H} .=5 \cdot 5$. G. $=5 \cdot 6-6 \cdot 9$.

Ullmannite or Nickel Stibine. An antimonial nickel sulphide, containing 25 to 28 per cent. of nickel. Color steel-gray, inclining to sil-ver-white. In cubical crystals, and also massive. $H=5-5.5 . \quad G .=0.45$. From the Duchy of Nassau.

Grinauite or Mismuth Nickel. A sulphide containing 31 to 38.5 of sulphar, 10 to 14 per cent. of bismath, with 22 to 407 of nickel. Color light steel-gray to silver-white ; often tarnished yellowish. H. $=$ 4.5 . $\quad .=513$. From the district of Altenkirchen, Prussia.

## Asbolite.-Earthy Cobolt. Black Cobalt Oxide.

Earthy, massive. Color black or blue-black. Soluble in muriatic acid, with an evolution of fumes of chlorine.

Obs. Occurs in an earthy state mixed with oxide of manganese as a bog ore, or secondary product. Abundant at Mine La Motte, Missouri, and also near Silver Bluff, South Carolina. The analyses vary in the proportion of oxide of cobalt associated with the manganese, as the compound is a mere mixture. Sulphide of cobalt occurs with the oxide. The Carolina ores afforded Cobalt oxide 24, manganese oxide 76. The ore from Missouri, as analyzed by Prof. Silliman, afforded 40 per cent. of cobalt oxide, with oxides of nickel, manganese, iron and copper.

This ore has been found abroad in France, Germany, Austria, and England.

The ore is purified and made into smalt, for the arts.

## Erythrite.-Cobalt Bloom. Hydrous Cobalt Arsenate.

Monoclinic. In oblique crystals having a highly perfect clearage, like mica; laminæ flexible in one direction. Also as an incrustation, and in reniform shapes, sometimes stellate.

Color, peach-red, crimson-red, rarely grayish or greenish ; streak a little paler, the dry powder lavender-blue. Lustre of laminæ pearly; earthy varieties without lustre. Trausparent to subtranslucent. $\quad \mathrm{H} .=1 \cdot 5-2 . \quad$ G. $=2.95$.

Composition. $\mathrm{Co}_{3} \mathrm{O}_{8} \mathrm{As}_{2}+8 \mathrm{aq}=$ Arsenic acid $38 \cdot 4$, oxide of cobalt $37 \cdot 6$, water $24^{\circ} 0$. B.B. on charcoal gives arsenical fumes and fuses; yields a blue glass with borax.

The earthy ore is sometimes called peach-blossom ore, from its color ; and also red cobalt ochre. Köttigite is a kind containing zinc.

Diff. Rosembles red antimony, but that species wholly volatilizes before the blowpipe. From red copper ore it differs in giving a blue glass with borax ; morcover, the color of the copper ore is more sombre.

Obs. Occurs with ores of lead and silver, and other cobalt ores. Schneeberg, in Saxony; Saalfield, in Thuringia; and Riechelsdorf, in Hessia, are noted European localities. It is found also in Dauphiny, Cornwall, and Cumberland.

Valuable as an ore of cobalt when abundant.
-........ . a a rose-red triclinic arsenate of cobalt.
Bieberite or Cobalt Vitriol. Has a flesh-red or rose-red tint, and astringent taste. $\mathrm{CoO} \mathbf{4} \mathbf{S}+7 \mathrm{aq}=$ Sulphuric acid 28.4 , cobalt oxide 25.5 , water 46.1 .

Morenosite. A nickel vitriol. $\mathrm{NiO} \mathrm{O}_{4} \mathrm{~S}+\mathrm{raq}$, having apple-green to greenish-white color. Lindackerite, hydrous nickel-copper arsenate.

Zaratite or Emerald Nickel. Incrusting, minute globular or stalactitic. Color bright emerald-green. Lustre vitreous. Transparent or nearly so. H. $=3-3 \cdot 25$. G. $=2 \%-2 \cdot \%$. It is a nickel carbonate, containing nearly 30 per cent. of water. B.B. infusible alone, but loses its color. Occurs with chromic iron and magnesium carbonate on serpentine, in Lancaster County, Pennsylvania.

Remingtonite. A hydrous nickel carbonate, rose-colored, from Finksburg, Md.

Spherocobraltite. A cobalt carbonate, $\mathrm{Co}_{3} \mathrm{C}$, from Saxony.
Nickel Silicates. Genthite is a hydrous magnesium and nickel silicate, of a pale apple-green color, yielding in one analysis 30 per cent. of nickel oxide. From Texas, Lancaster County, Pa., and other localities. Rottisite, from Röttis, Voigtland, is similar. Pimelite is an impure apple-green silicate, affording in one case 15.6 per cent. of nickel oxide. Alipite is similar ; so also Garniurite (and Nouncitc), from New Caledonia, and worked there for nickel.

Ceneral Remarks.-The two arsenical ores of cobalt afford the greater part of the cobalt of commerce. The earthy oxide when albundant is a profitable source of the metal. Erythrite (Cobalt Bloom) occurs abundantly with other cobalt ores at its localities in Saxony, Thuringia and Hesse Cassel. Arsenopyrite (mispickel) yields at times 5 to 9 per cent. of cobalt. Cobalt is never employed in the arts in a metallic state, as its alloys are brittle and unimportant. It is chiefly used for painting porcelain and pottery, and is required for this purpose in the state of an oxide, or the silicated oxide called smalt aud azure. Zaffre is an impure oxide obtained in the calcining of the ore with twice its weight of sand; and from it the smalt and azure are produced. Nickel is worked in Germany, Austria, Russia, Sweden, England, United States, and New Caledonia. It is obtained largely from the copper nickel (niccolite) and chloanthite, or from an artificial product called speiss (an impure arsenide), derived from roasting ores of cobalt containing nickel; from siegenite (or nickel-linnæite), a sulphide of cobalt and nickel ; from millerite), in part ; from the apple-green silicate; and largely from pyrrhotite or "magnetic iron pyrites." At the Gap Mine, near Lancaster, Pa., the ore 18 millerite and pyrrhotite ; in Missouri, the siegenite; in New Caledonia, chiefly the silicate.

Nickel also occurs in meteoric iron, forming an alloy with the iron, which is characteristic of most meteorites. The proportion sometimes exceeds 20 per cent.

As nickel does not rust or oxidize (except when heated), it is superior to steel for the manufacture of many philosophical instruments. As alloy of copper, nickel, and zinc (one-sixth to one-third nickel), constitutes the German silver, or argentane.
"German silver" is not a very recent discovery. In the reign of William III., an act was passed making it felony to blanch copper in
imitation of silver, or mix it with silver for sale. "White copper" has long been used in Saxony for various small articles; the alloy employed is stated to consist of copper 88.00 , nickel 8.75 , sulphur with a little antimony $0 \% 5$, silex, clay, and iron $1 . \% 5$. A similar alloy is well known in China, and is smuggled into various parts of the East Indies, where it is called packfong. It has been sometimes identified with the Chinese tutenague. M. Meurer analyzed the white copper of China, and found it to consist of copper $65 \% 24$, zinc 19.52 , nickel 13, silver 2.5 , with a trace of cobalt and iron. Dr. Fyfe obtained copper $40 \cdot 4$, nickel $31 \cdot 6$, zinc $25 \cdot 4$, and iron $2 \cdot 6$. It has the color of silver, and is remarkably sonorous. It is worth in China about one-fourth its weight of silver, and is not allowed to be carried out of the empire.

An alloy of 88 per cent. copper and 12 per cent. nickel is the material of the United States cent, introduced in 1851. Switzerland, Belgium and Jamaica also have used a nickel alloy for coins.

Nickel is mostly used at the present time for nickel-plating by electrodeposition. The value of the metal in commerce rose in the years 1870 to 1875 , from $\$ 125$ to $\$ 3.00$ per pound. The amount annually produced is about 600 tons.

## URANIUM.

Uranium ores have a specific gravity not above 7, and a hardness below 6 . The ores are either of some shade of light green or yellow, or they are dark brown or black and dull, or submetallic and without a metallic lustre when powdered. They are not reduced when heated with carbonate of soda; and the brown or black species fuse with difficulty on the edges or not at all.

> Uraninite,-Pitchblende. Uranium Oxide.

Isometric. In octahedrons and related forms. Also massive and botryoidal. Color grayish, brownish, or velvetDlack. Lustre submetallic or dull. Streak black. Opaque. $\mathrm{H} .=5 \cdot 5 . \quad \mathrm{G} .=6 \cdot 4 \%$.

Composition. 75 to 87 per cent. of uranium oxides with silica, lead, iron, and some other impurities. Related to the spinel group. B.B. infusible alone ; a gray scoria with borax. Dissolves slowly in nitric acid, when powdered.

Obs. Occurs in veins with ores of lead and silver in Saxony, Bohemia, and Hungary ; also in the tin mines of Cornwall, near Redruth. In the United States, very sparingly at Middletown, Redding, and Haddam, Conn.; in North Carolina; on the north side of Lake Superior (Coracite).

The oxides of uranium are used in painting upon porcelain, yielding a fine orange in the enameling fire, and a black color in that in which the porcelain is baked.

Cleveitf. Hydrated oxide of uranium, inon, erbium, corium, yttrium, in cubic forms. From Norway.

Gummite. An amorphous uranium ore, looking like gum, of a reddish or brownish color. It is a hydrous uraninite, and has resulted from its alteration. Occurs at Johanngeorgeustadt, and in North Carolina.

Eliasite. Another hydroas ore, more or less resin-like in aspect, of a reddish-brown to black color.

Hatchettolite. A hydrous columbo-tantalate of uranium, in isometric octahedrons, resembling pyrochlore from North Carolina. G. $=$

Blomstrandite. A hydrous titano-columbate, from Sweden.

> Torbernite.-Uranite. Chalcolite. Uran-Mica.

Dimetric. In square tables, thinly foliated parallel to the base, almost like mica; laminæ brittle.

Color emerald and grass-green; streak a little paler. Lustre of laminx pearly. Transparent to subtranslucent. $\mathrm{H} .=2-2 \cdot 5 . \quad$ G. $=3 \cdot 4-3 \cdot 6$.

Composition. A uraninm-copper phosphate, consisting if pure of Phosphorus pentoxide $15 \cdot 1$, uranium trioxide $61 \cdot 2$, copper oxide $8 \cdot 4$, water $15 \cdot 3=100$. B. B. fuses to a blackish mass, and colors the flame green.

Diff. The micaceous structure, connected with the bright green color and square tabular form of the crystals, are striking characters. The folia of mica are not brittle, like those of uranite.

Ots. Occurs with uranium, silver and tin ores. It is found at St. Symphorien, in splendid crystallizations, near Redruth and elsewhere in Cornwall ; in the Saxon and Bohemian mines ; in North Carolina.

Autunite is similar to torbernite ; bat has a bright citron-yellow color, and is a uranium-calcium phosphate. From the same mining regions, also from near Autun in France, and sparingly, from Portland, Middletown, and Redding, Conn.; Acworth, N. H.; Chesterfield, Mass.; and in North Carolina.

Uranospinite is an autunite containing arsenic instead of phosphorus; and Zeunerite is a torbernite containing arsenic instead of phosphorus.
Samarsfite (formerly named uranotantalite and yttroilmenite) is a compound of oxyd of uranium with columbic and tangstic acids, from Miask in the Ural. It is of a dark brown color and submetallic lustre. G. $=5 \cdot 4-5 \%$. Abundant in North Carolina.

> Johannite or Uranvitriol is a sulphate of uranium. It has a fine emerald-green color, and a bitter taste. From Bohemia.
> Trogerite and Walpurgite are uranium arsenates. Voglite and Lietigite are uranium carbonates. Johannite is a uranium vitriol; Uranochalcite, Medijditc, Zippeite, Voglianite, Uraconite, are other uranium sulphates.

> Uranocircite is a hydrous barium-uranium phosphate.
IRON.

Iron occurs native, and alloyed with nickel in meteoric iron. Its most abundant ores are the oxides and sulphides. It is also found combined with arsenic, forming arsenides and sulpharsenides; with oxygen and other metals, as chromium, aluminum, magnesium ; and in the condition of sulphate, phosphate, arsenate, columbate, silicate and carbonate, of which the last is an abundant and valuable ore. Its ores are widely disseminated. The oxides and silicates are the ordinary coloring ingredients of soils, clays, carth and many rocks, tinging them red, yellow, dull green, brown and black.

The ores have a specific gravity below 8 , and the ordinary workable ores seldom exceed 5. Many of them are infusible before the blowpipe, and nearly all minerals containing iron become attractable by the magnet after heating, when not so before. By their difficult fusibility, the species with a metallic lustre are distinguished from ores of silver and copper, and also more decidedly from these and other ores by blowpipe reaction.

## Native Iron.

Isometric. Usually massive with octahedral clearage.
Color and streak iron-gray. Fracture hackly. Malleable and ductile. $\quad \mathrm{H} .=4 \cdot 5 . \quad \mathrm{G} .=7 \cdot 3-7 \cdot 8$. Acts strongly on the magnet.

Obs. Native iron occurs in grains disseminated through some dolcryte, basalt, and other related igneous rocks ; and in Greenland, in very large masses in such igneous rocks, the largest weighing over a ton. It is suggested by $J$. Lawrence Smith, that the iron was reduced by means of carbohydrogen vapors, taken into the rock from carbonaceous rocks passed through on the way to the surface.

It is a constituent of nearly all metoorites, and the chief ingredient in a large part of them; and in this state it is with a rare exception alloyed with nickel, and with traces of cobalt and copper. The Texas meteorite, of Yale College, weighs 1,635 pounds ; the Pallas meteorite, now at Vienna, originally 1,600 ; but one in Mexico, the San Gregorio meteorite, is stated to weigh five tons; and one in the district of Chaco-Gualamba, S. A., nearly fifteen tons. Meteoric iron often has a very broad crystalline structure, long lines and triangular figures being developed by putting nitric acid on a polished surface. The coarseness of this structure differs in different meteorites, and serves to distinguish specimens not identical in origin. Nodules of troilite ( FeS ), and schrcibersite (iron phosphide) are common in iron meteorites. Mcteoric iron may be worked like ordinary malleable iron. The nickel diminishes the tendency to rust. But some kinds contain iron chloride, or are open in texture, and rust badly.

Pyrite.-Iron Pyrites. Iron Bisulphide.


Usually in cubes, the strix of one face at right angles with those of either adjoining face, as in fig. 1. Also
figs. 2 to 7 ; also figs. 8 to 15 on page 6. Fig. 6, a pentagonal dodecahedron, is a common form. Occurs also in imitative shapes, and massive.

Color bronze-ycllow; streak brownish black. Lustre of crystals often splendent metallic. Brittle. II. $=6-6 \cdot 5$, being hard enough to strike fire with steel. G. $=4 \cdot 8-5 \cdot 1$.

Composition. Fe $\mathrm{S}_{2}=$ Sulphur $53 \cdot 3$, iron $46 \cdot \%=100$. B.B. on charcoal gives off sulphur, and ultimately affords a globule attractable by the magnet.

Pyrite often contains a minute quantity of gold, and is then called auriferous pyrite. See under Gold. Nickel, cobalt and copper occur in some pyrite.

Diff. Distinguished from copper pyrites in being too hard to be cut by a knife, and also in its paler color. The ores of silver, at all resembling pyrite, instead of having its pale bronze-yellow color, are steel-gray or nearly black; and besides, they are easily ecratched with a knife and quite fusible. Gold is sectile and malleable.

Obs. Pyrite is one of the most common ores on the globe. It occurs in rocks of all ages. Cornwall, Elba, Piedmont, Sweden, Brazil, and Peru, have afforded magnificent crystals. Alston Moor, Derbyshire, Kongsberg in Norway, are well-known localities. It has also been observed in the Vesuvian lavas, and in many other igneous rocks.

In the United States, the localities are numerous. Fine crystals have been met with at Rossie, N. Y. ; at many other places in that State ; also in each of the New England States and in Canada; in New Jersey, Pennsylvania, Virginia, North Carolina, Georgia, in Colorado, Wyoming and the States west. It occurs in all gold regions, and is one source of gold.

This species is of the highest importance in the arts, although not affording good iron on account of the difficulty of separating entirely the sulphur. It affords the greater part of the sulphate of iron (green vitriol or copperas) and sulphuric acid (oil of vitriol) of commerce, and also a considerable portion of the sulphur and alum. To make the sulphate the pyrites is sometimes heated in clay retorts, by which about 17 per cent. of sulphur is distilled over and collected. The ore is then thrown out into heaps, exposed to the atmosphere, when a change ensues by which the remaining sulphur and iron become through oxidation sulphate of iron. The material is lixiviated, and partially eva-
porated, preparatory to its being run off into vats or troughs to crystallize. In other instances, the ore is coarsely broken up and piled in heaps and moistened. Fuel is sometimes used to commence the process, which afterwards the heat generated continues. Decomposition takes place as before, with the same result. Cabinet specimens of pyrite, especially granular or amorphous masses, often undergo a spontaneous change to the sulphate, particularly when the atmosphere is moist.

Pyrite, owing to its tendency to oxidation, and its very general distribution in rocks of all kinds and ages, is one of the chief sources of the disintegration and destruction of rocks. No granite, sandstone, slate, or limestone, containing it, is fit for architectural purposes or for any outdoor uses. The same destructive effects come from pyrrhotite and marcasite, which also are widely diffused.

The name pyrites is from the Greek pur, fire, because, as Pliny states, "there was much fire in it," alluding to its striking fire with steel. This ore is the mundic of miners.

[^1]
## Pyrrhotite.-Magnetic Pyrites. Iron Sulphide.

Itexagonal. Occurs occasionally in hexagonal prisms, which are often tabular ; generally massive.

Color between bronze-yellow and copper-red ; streak dark grayish-black. Brittle. $\quad \mathrm{H} .=3 \cdot 5-4 \cdot 5 . \quad$ G. $=4 \cdot 4-4 \cdot 65$. Slightly attracted by the magnet. Liable to speedy tarnish.

Composition. $\mathrm{Fe}_{7} \mathrm{~S}_{8}=$ Sulphur $39 \cdot 5$, iron $60 \%$. It is often a valuable ore of nickel, containing sometimes 3 to 5 per cent. of this metal. B.B. on charcoal in the outer flame it is converted into red oxide of iron. In the inner flame it fuses and glows, and affords a black globule which is magnetic, and has a yellowish color on a surface of fracture.

Diff. Its inferior hardness and shade of color, and its
magnetic quality distinguish it from pyrite; and its paleness of color from chalcopyrite or copper pyrites.

Obs. Crystallized specimens have been found at Kongsberg in Norway, and at Andreasberg in the Hartz. The massive variety is found in Cornwall, Saxony, Siberia, and the Hartz ; also at Vesuvius and in meteoric stones.

In the United States, it is met with at Trumbull and Monroe, New Fairfield, and Litchfield, Conn. ; at Strafford and Shrewsbury, Vt.; at Corinth, New Hampshire; in many parts of Massachusetts and New York; at Lancaster, Pa., where it is worked for nickel. It is used for making green vitriol and sulphuric acid, like pyrite.

Troitite is a similar mineral of the formula FeS , occurring in meteorites. Schreibersite is a phosphide of iron and nickel, occurring in meteorites.

## Arsenopyrite.-Mispickel. Arsenical Iron Pyrites.

Trimetric. In rhombic prisms, with cleavage parallel to the faces $I ; I \wedge I=111^{\circ} 40^{\prime}$ to $112^{\circ}$. Crystals sometimes elongated horizontally, producing a rhombic prism of $100^{\circ}$ nearly, with $I$ and $I$ the end planes. Occurs also massive.

Color silver-white ; streak dark grayish-black. Lustre shining. Brittle. H. $=5 \cdot 5-6$. G. $=6 \cdot 3$.

Composition. Fe AsS $=$ Arsenic $46 \cdot 0$,
 sulphur $19 \cdot 6$, iron $34 \cdot 4=100$. A cobaltic variety contains 4 to 9 per cent. of cobalt in place of part of the iron ; Danaite of New Hampshire, consists of Arsenic $41 \cdot 4$, sulphur $17 \cdot 8$, iron $32 \cdot 9$, cobalt $6 \cdot 5$. B.B. affords arsenical fumes, and a globule of iron sulphide which is attracted by the magnet. In the closed tube a sublimate of arsenic sulphide. Gives fire with a steel and emits a garlic odor.

Diff. Resembles arsenical cobalt, but is much harder, it giving fire with steel; it differs also in yielding a magnetic globule before the blowpipe, and in not affording the reaction of cobalt with the fluxes.

Obs. Arsenopyrite is found mostly in crystalline rocks, and is commonly associated with ores of silver, lead, iron, or copper. It is abundant at Freiberg, Munzig, and elsewhere in Europe, and also in Cornwall, England.

It occurs in crystals in New Hampshire, at Franconia, Jackson, and Haverhill ; in Maine, at Blue Hill Bay, Corinth, Newfield, and Thomaston; in Vermont, at Waterbury; in Massachusetts, massive at Worcester and Sterling ; in Connecticut, at Chatham, Derby, and Monroe ; in New Jersey, at Franklin; in New York, in Lewis, Essex County, and near Edenville and elsewhere in Orange County ; in Kent, Putnam County.

Leucopyrite. This is the name of arsenical iron $\mathrm{Fe}_{2} \mathrm{As}_{3}$. It resembles the preceding in color and in its crystals. $I \wedge I=122^{\circ} 20^{\circ}$. It has less hardness and higher specific gravity. $\mathrm{H}=5=5-5 \cdot 5 . \quad \mathrm{G} .=7 \cdot 2$ $-7 \cdot 4$. Contains Iron $32 \cdot 2$, arsenic 669 , with some sulphur. From Styria, Silesia, and Carinthia.

Löllingite is another iron arsenide, $\mathrm{Fe} \mathrm{As}_{2}=$ Arsenic 72.8, iron 27.2 ; specific gravity $6 \cdot 8-8 \cdot 71$. Berthierite is an iron sulphantimonite.

## Hematite.-Specular Iron Ore. Iron Sesquioxide.

Rhombohedral. In complex modifications of a rhombohe-
1.

2.

3.

dron of $86^{\circ} 10^{\prime}$ (fig. 1); crystals occasionally thin tabular. Cleavage usually indistinct. Often massive granular ; sometimes lamellar or micaceous. Also pulverulent and earthy.

Color dark steel-gray or iron-black, and often when crystallized having a highly splendent lustre; streak-powder cherry-red or reddish-brown. The metallic varicties pass into an earthy ore of a red color, having none of the external characters of the crystals, but perfectly corresponding to them when they are pulverized, the powder they yield being of a deep red color, and earthy or without lustre. G. $=4 \cdot 5-5 \cdot 3$. Hardness of crystals $5 \cdot 5-6 \cdot 5$. Sometimes slightly attracted by the magnet.

## varieties.

Specular iron. Having a perfectly metallic lustre.

## Micaceous iron. Structure foliated.

Red hematite. Submetallic, or unmetallic, and of a brown-ish-red color.

Red ochre. Soft and earthy, and often containing clay.

Red chalk. More firm and compact than red ochre, and of a fine texture.

Jaspery clay iron. A hard impure siliceous clayey ore, and having a brownish-red jaspery look and compactness.

Clay iron stone. The same as the last, the color and appearance less like jasper. But this is one variety only of what is called "clay iron stone," a name covering also a related variety of siderite and limonite.
Lenticular argillaceous ore. A red ore, consisting of small flattened grains.
Martite is hematite in octahedrons, derived, it is supposed, from the oxidation of magnetite.

Composition. $\quad \mathrm{Fe}_{0} \mathrm{O}^{3}=0$ xygen 30 , iron $70=100$. B.B. alone infusible. Heated in the inner flame it becomes strongly magnetic.
Diff. The red powder of this mineral, and the magnetism which is so easily induced in it by a reduction flame distinguish hematite from all other ores. The word hematite, from the Greek haima, blood, alludes to the color of the powder.

Obs. This ore occurs in crystalline and stratified rocks of all ages. The more extensive beds of pure ore abound in Archean rocks; while the argillaceous varieties occur in stratified rocks, being often abundant in coal regions and among other strata. Crystallized specimens are found also in some lavas, as a volcanic product.

Splendid crystallizations of this ore come from Elba, whose beds were known to the Romans; also from St. Gothard ; Arendal, Norway ; Longbanshyttan, Sweden ; Lorraine and Dauphiny. Etna and Vesuvius afford handsome specimens.
In the United States, this is an abundant ore. The two Iron Mountains of Missouri, situated 90 miles south of St. Louis, consist mainly of this ore, piled "in masses of all sizes from a pigeon's egg to a middle-size church." One of them is 300 feet high, and the other, the "Pilot Knob," is 700 feet. The massive and micaccous varieties occur there together with red ochroous ore. Large beds occur in Essex, St. Lawrence and Jefferson counties, N. Y., and at Marquette, in Michigan; the micaceous variety, at Hawley, Mass., Piermont, N. II., and in Stafford County, Va.; lenticular argillaceous ore abundantly in Oneida, Herkimer, Madison and Wayne counties. N. Y., constituting one or two beds of the Clinton group (Upper Silurian), in a compact sandstone;
and the same is found in Pennsylvania and south to Alabama, and also in Wisconsin ; it contains 50 per cent. of oxide of iron, with about 25 of carbonate of lime and more or less magnesia and clay. The coal region of Pennsylvania affords abundantly the clay iron ores, but they are mostly cither the argillaceous carbonate or limonite.

Valuable as an iron ore, though less casily worked when pure and metallic than the magnetic and hydrous ores. Pulverized red hematite is used for polishing motal. Red chalk is a well-known material for red pencils.

> Menaccanite.-Ilmenite. Titanic Iron. Washingtonite.

Rhombohedral. $R, \wedge R=83^{\circ} 31^{\prime}$. Often in thin plates or seams in quartz; also in grains. Crystals sometimes very large and tabular.

Color iron-black; streak submetallic. Lustre metallic or submetallic. H. $=5-6 . \quad$ G. $=4 \cdot 5-5$. Acts slightly on the magnetic needle.

Composition. Like that of hematite, except that part of the iron is replaced by titanium ; the amount replaced is very variable. Infusible alone before the blowpipe.
l)iff. Near specular iron, but its powder is not red.

Obfs. Crystals, an inch or so in diameter, occur in Warwick, Amity and Monroc, Orange County, N. Y. ; also near Elenville and Greenwood Furnace ; also at South Royalston and Goshen, Mass. ; at Washington, South Britain, and Litehfield, Conn. ; at Westerly, Rhode Island.

It is of no value in the arts and is a deleterious constituent of many iron ores.

Magnetite.-Magnetic Iron Ore.
Isometric. Often in octahedrons (fig. 12), and dodecahe-
 drons (fig. 13). Cleavage octahedral ; sometimes distinct. Also granularly massive. Occasionally in dendritic forms between the folia of mica.
('olorirom-black. Streak black. Brittle. If. $=5 \cdot 5-6 \cdot 5 . \quad$ ( $1=5 \cdot 0$ -51 . Strongly atiracted by the
 magnet, and sometimes having polarity.

Composition. $\mathrm{FeHeO}=\mathrm{FeO}_{4}+\mathrm{HeO}_{3}=O x y g e n 24 \cdot 6$, iron
$72 \cdot 4=100$. Infusible before the blowpipe. Yields a yellow glass when fused with borax in the outer flame.

Diff. The black streak and strong magnetism distinguish this species from the following.

Obs. Magnetic iron ore occurs in extensive beds, and also in disseminated crystals. It is met with in granite, gnciss, mica schist, clay slate, syenyte, hornblende and chlorite schist ; and also sometimes in limestone.

The beds at Arendal, and nearly all the Swedish iron ore, consist of massive magnetic iron. At Dannemora and the Taberg in Southern Sweden, and also in Lapland at Kurunavara and Gelivara, there are mountains composed of it.

In the United States it constitutes extensive beds, in Archoan rocks, in Warren, Essex, Olinton, Orange, Putnam, Saratoga and IIerkimer counties, New York; and in Sussex and Warren counties, in New Jersey. Smaller deposits occur in the sereral New England States and Canada. Also found at Magnet Cove, in Arkansas; in Califormia, in Sierra (County, and elsewhere. It exists with homatite in the Iron Mountains of Missouri.

Marese of this ore, in a state of magnetic polarity, constitute what are called lodestones or native magncts. They are met with in many leds of the ore. Siberia and the Hartz have afforded fine specimens; also the Island of Elba. They also oceur at Marshall's Island, Maine; also near Providence, Rhode lsland, and at Magnet Cove, in Arkansas. The loflestome is called magnes liy Pliny. from the name of the country, Magnesia (a prorince of ancient Lydia), where it was found; and it hence gave the terms magnet and magnotism to science.

## Franklinite.

Isometric. In octahedral and dodecahedral crystals. Also coarse gramular massive. Color iron-black; streak dark reddish-brown. Brittle. II. $=55-6 \cdot 5 . \mathrm{G} .=4 \cdot 85-5 \cdot 1$. Usually is attracted hy the magnet.

Composition. General formula like that of magnetite, RR $\mathrm{O}_{4}$, but having ziuc and manganese replacing part of the iron, as indicated in the formula ( $\mathrm{Fe}, \mathrm{Zn}, \mathrm{Mn}$ ) $(\mathrm{Fe}, \mathrm{Mn}) \mathrm{O}_{4}$. A common tariety corresponds to $\mathrm{Fe}_{2} \mathrm{O}_{3} 67 \cdot 6, \mathrm{Fe} \mathrm{O} 5 \cdot 8, \mathrm{ZnO}$ $6 \cdot 9, \mathrm{Mn} \mathrm{O} 9 \cdot \%=100$.
13.B. with soda on charcoal a zine coating is obtained ; a
soda bead in the outer flame is colored green by the manganese.

Diff. Resembles magnetic iron, but the exterior color is a more decided black. The streak is reddish brown, and the blowpipe reactions are distinctive.

Obs. This is an abundant ore at Sterling and Hamburg, in New Jersey, near the Franklin Furnace; at the former place the crystals are sometimes four inches in diameter ; also amorphous at Altenberg, near Aix-la-Chapelle.

## Chromite.-Chromic Iron.

Isometric. In octahedral crystals, without distinct cleavage. Usually massive, and breaking with a rough unpolished surface.

Color iron-black and brownish black ; streak dark brown. Lustre submetallic; often faint. H. $=5 \cdot 5$. G. $=4 \cdot 3-4 \cdot 6$. In small fragments attractable by the magnet.

Composition. General formula RR $O_{4}$, as for magnetita; but part of the iron is replaced by chrominm. Analysis gives Iron protoxide 32, chromium sesquioxide $68=100$; aluminum and marnesium also are commonly present in variable amounts, replacing the other constituents. B.B. infusible alone; with borax a beautiful green bead.

This ore usually possesses a less metallic lustre than the other black iron ores.

Obs. Oceurs usually in serpentine rocks, in imbedded masses or veins. Some of the foreign localities are the Gulsen Mountains in Styria; the Shetland Islands; the department of Var in France ; Silesia, Bohemia, ete.

In the United States it is abundant: in Maryland in the Bare Lills, near Baltimore, and also in Montgomery County, at Cooptown, in Harford County ; and in the north part of Cecil County ; occurs also in Townsend and Westfield, Vermont, and at Chester and Blandford, Mass. It is also found in Pennsylvania, at Wood's Mine, near Texas, Lancaster County, in West Branford, Chester County ; at Bolton and Ham, Canada East ; in California near New Idria; also in Sonoma County ; Tuolumne County, near Crimea House, and elsewhere ; at Seattle in Wyoming.

The compounds of chromium, which are extensively used as pigments, are obtained chiefly from this ore. Meteorites have afforded a chromiam-sulphide, named Daubréelite.

## Limonite.-Brown Ilematite.

Usually massive, and often with a smooth botryoidal or stalactitic surface, having a compact fibrous structure within. Niso earthy.

Color dark brown and black to ochre-yellow ; streak yellowish brown to dull yellow. Lustre sometimes submetallic ; often dull and earthy; on a surface of fracture frequently silky. H. $=5-5 \cdot 5 . \quad$ G. $=3 \cdot 6-4$.

The following are the principal varieties:
Brown hematite. The botryoidal, stalactitic and associated compact ore.

Brown ochre, Yellow ochre. Earthy ochreous varieties, of a brown or yellow color.

Brown and Iellow cley iron stone. Impure ore, hard and compact, of a brown or yellow color.

Bog iron ore. A loose carthy ore of a brownish-black color, occurring in low grounds.

Compostion. $\mathrm{E}^{(\mathrm{O}} \mathrm{O}_{9} \mathrm{II}_{6}\left(=2 \mathrm{Fe}_{3}+3 \mathrm{II}_{2} \mathrm{O}\right)=$ Iron sesquioxide $85 \%$, water $14 \cdot 4=100$; or it is a hydrous iron sesquioxide, containing, when pure, abont two-thirds its weight of pure iron. B.B. blackens and becomes magnetic; with borax in the outer flame a yellow glass.
I)iff. This is a much softer ore than cither of the two preceding, and is peculiar in its frequent, stalactitic forms, and in its affording water when heated in a glass tube.

Obs. Occurs comnected with rocks of all ages, but appears, as shown by the stalactitic and other forms. to have resulted in all cases from the decomposition of other iron ores.

An abundant ore in the United States. Extensive beds exist in Salishury and Kent, Conn., also in the neighboring towns of Beekman, Fishkill, Dover, Amenia. N. Y.; also in a similar situation north, in Richmond and Werst Stockbridge, Mass. ; also in Bennington, Monkton, Pittsford, Putney, and Ripton, Vermont. Large beds are found in Pennsylvania, the Carolinas, near the Missouri Iron Mountains, and also in Tennessee, Iowa and Wisconsin.

This is one of the most valuable ores of iron. The limonite of Western New England, and that along the same range geologically in Dutchess Countr, New York, Eastern Pennsylvania, and beyond, is remarkably free from phosphorus, and hence is highly valued for its iron. Bog ores
usually contain much phosphorus, from organic sources, and hence the iron afforded is best fitted for castings. Limonite is also pulverized and used for polishing metallic buttons and other articles. As yellow ochre, it is a common material for paint.

Gothite (Pyrrhosiderite, Lepidokrokitc) is another iron hydrate, often in prismatic crystals, as well as fibrous and massive, of the formula Fe $\mathrm{O}_{4} \mathrm{H}_{2}\left(=\mathrm{EeO}_{3}+\mathrm{H}_{2} \mathrm{O}\right)$, and $\mathrm{G} .=4 \cdot 0-4 \cdot 4$.

Turgit, has the formula $\mathrm{Fe}_{7} \mathrm{H}_{2}=2 \mathrm{EeO}_{3}+\mathrm{I}_{2} \mathrm{O} . \quad$ Santhosidcrite and limnite are other related hydrates.

Melanterite.-Copperas. Iron Titriol. Green Vitriol.
Monoclinic. In acute oblique rhombic prisms. $I \wedge I=$ $82^{\circ} 21^{\prime} ; O \wedge I=80^{\circ} 37^{\prime}$. Cleavage parallel to $O$ perfect. Generally pulverulent or massive.

Color greenish to white. Lustre vitroous. Subtransparent to translucent. Taste astringent, sweetish, and metallic. Brittle. H. $=2$. G. $=1 \cdot 83$.

Composition. $\mathrm{Fe} \mathrm{O}_{4} \mathrm{~S}+7 \mathrm{aq}=$ Sulphur trioxide $28 \cdot 8$, iron protoxide $25 \cdot 9$, water $45 \cdot 3=100$. B.13. becomes magnetic. Yields glass with lorax. On exposure, becomes covered with a yellowish powder, which results from oxidation.

Obs. This species is the result of the decomposition of pyrite and pyrrhotite, which readily afford it if moistened while exposed to the atmosphere, and it is ohtained from these sulphides for the arts (p. 1\%3). An old mine near Goslar, in the Hartz, is a noted jocality.

Copperas is much used by dyers and tanners, on account of its giving a black color with tannic acid, an ingredient in nutgalls and many kinds of bark. It for the same reason forms the basis of ordinary $i n k$, which is essentially an infusion of nutgalls and copperas. It is also employed in the manufacture of Prussion blue. With potassiom ferrocyanide, any soluble salt of iron seaquioxide, ceven in minute quantity, gives a fine blue color to the solation (due to the formation of Prussian blue), and this is a delicate test of tho presence of iron.
Coquimbits, Copiapite, Toltaite, Raimondite, Botryogen, Fibroferrite, Ihleite, are names of other hydrous iron sulphates ; and Hulotrichite is an iron-alum.

Jarosite is a hydrous iron-potash sulphate.
Pisenite is an iron-copper vitricl.
Lagonite. A hydrous iron borate, from the Tuscan lagoons.

## Wolframite.-Wolfram. Iron-Manganese Tungstate.

Monoclinic. Sometimes pseudomorphous in octahedrons formed by the alteration of tungstate of lime. Also massive. Color dark grayish-black; streak dark reddish-brown. Lastre submetallic, shining, or dull. II. $=5-5 \cdot 5 . \quad \mathrm{G} .=$ $7 \cdot 1-7 \cdot 5$.

Composition. ( $\mathrm{Fe}, \mathrm{Mn}) \mathrm{O}_{4} \mathrm{~W}$. A typical variety affords tungsten trioxide $76 \cdot 47$, iron protoxide 9.49 , manganese protoxide $14 \cdot 04=100$. A manganese wolframite has been named Hübnerite. B.B. fuses casily to a magnetic globule ; with aqua regia dissolved with the separation of ycllow tungsten trioxide.

Found often with tin ores. Occurs in Cornwall, and at Zinnwald and elsewhere in Europe. In the United States it is found at Monroe and Trumbull, Coun.; on Camdage Farm, near Blue Hill Bay, Me.; near Mine la Motte, Missouri ; in the gold regions of North Carolina; in Mammoth Mining district, Nevada Hubnerite.

## Columbite.

Trimetric. In rectangular prisms, more or less modified. Also massive. Cleavage paralle to the lateral faces of the prism, somewhat distinet.
( Golor iron-black, brownish-black ; often with a characteristic iridescence on a surface of fracture ; streak dark brown, slightly reddish. Lustre submetallic, shining. Opaque. Brittle. H. $=5-6 . \quad(\mathrm{x} .=5 \cdot 4-6 \div 5$.
('umposilion. Iron columbate, of the formula $\mathrm{F} \mathrm{O}_{6} \mathrm{Cb}_{2}=$ Columbium
 pentoxide 79.6 , iron protoxide 164 , manganese protoxide 4.4 , tin oxide 0.5 , lead and copper oxides $0 \cdot 1=100$. Tantalum often replaces part of the colambium, and in this case the mineral is of higher specific gravity. B. B. alone infusible. It imparts to the borax bead the yellow color of iron.

Diff. Its dark color, submetallic lustra, and a slight iridescence, together with its loreaking readily into angular fragments, will generally distinguish this species from the ores it resembles.

Obs. Occurs in granite at Bodenmais in Bavaria, and also in Bohemia. In the United States, it is found in granitic reins, at Middletown and Haddam, Conn. ; at Ohesterfield and Beverly, Mass. ; at Acworth, N. II. ; Greenfield, N. Y. A crystal was found at Middletown, which originally weighed i4 pounds avoirdupois ; and a part of it, 6 inches in length and breadth, weighing ( 6 lhs .12 oz ., is now in the collections of the Wesleyan University of that place. Also at Standish, Maine ; and in granite veins in North Carolina.

This mineral was first made known from American specimens, by Mr. Hatchett, an English chemist, and the new metal it was found to contain was named by him columbium.

Tantalite. $\mathrm{Fe}(\mathrm{Mn}) \mathrm{O}_{\mathrm{s}} \mathrm{Ta}_{2}$. This tantalate of iron is allied to columbite. H. 6-6\%. G. 7-8. It is distinguished by its higher specific gravity. It sometimes contains tin and tungsten. From Finland, Sweden, near Limoges in France, and from North Carolina and Alabana.

Note.-The metal named Columbium by Hatchett, is the same that has since been called Niovium, without any good reason for the change of name.

Triphylite. An iron manganesc-lithium phosphate. See p. 190.
Vivianite.-IIydrous Iron Phosphate.
Monoclinic. In modified oblique prisms, with cleavage in one direction highly perfect. Also radiated, reviform, and globular, or as coatings.

Color deep blue to green. Crrstals usually green at right angles with the vertical axis, and blue parallel to it. Streak bluish. Lastre pearly to vitreons. Transparent to translucent; opaque on exposure. Thin laminæ flexible. II. = $15-2 . \quad \mathrm{G} .=266$.

Composition. $\quad \mathrm{Fe}_{3} \mathrm{O}_{4} \mathrm{P}_{2}+8 \mathrm{aq}=$ Phosphorus pentoxide, $28 \cdot 3$, iron protoxide $43 \cdot 0$, water $28 \cdot 7=100$. B. B. fuses casily to a magnetic globule, coloring the flame greenish blue. Affords water in a glass tube, and dissolves in hydrochloric acid.

Diff. The deep blue color and the little hardness are decisive characteristics. The blowpipe affords confirmatory tests.

Obs. Found with iron, copper and tin ores, and sometimes in clay, or with bog iron ore. St. Agnes in Cornwall, Bodenmais, and the gold mines of Vöröspatak in Transylvania, afford fine crystallizations. In the United States, grood
crystals have been found at Imlaystown, N. J. At Allentown, Monmouth County, and Mullica Hill, Gloucester County, N. J., are other localities. It often fills the interior of certain fossils. Occurs also at Harlem, N. Y., in Somerset and Worcester counties, Md., and with bog ore in Stafford County, Va. Abundant at Vandreuil in Canada, where it is associated with limonite.

The bluc iron earth is an earthy raricty, containing about 30 per cent. of phosphoric acid.

Ludlamite. A clear green hydrous phosphato of iron in monoclinic crystals; from Cornwall.

Dufrenite. A hydrous phosphate of iron sesquioxide. It has a dull green color, and is often found in radiated forms.

Cacoxenite. Occurs in radiated silky tufts of a yellow or yellow-ish-brown color. H. $=3-4 . \quad G .=3.38$. It is a phosphate of iron sesquioxide, and often contains alumina. It differs from wavellite, which it resmmbles, in its more yellow color and iron reactions. It also resembles carpholite, but has a deeper color, and does not givo the manganese reactions. It occurs on brown iron ore in Bohemia.

Chalcosiderite and Andrcusitr are other iron phosphates.
Strengite. A lyydrous iron phosphate related in formula to scorodite. From near Giessen.

## Arsenates of Iron.

Pharmacosiderite, or Cube ore. Occurs in cubes of dark green to brown and red colors. Lustre adamantine, not very distinct. Streak greenish or brownish. H. $=\mathbf{2} 5 . \quad G .=3$. It is a liydrous arsenate of iron sesquioxide, containing 43 per cent of arsenic pentoxide. From the Cornwall mines; also from France and Saxony.

Scorudite. Crystallizen in rhombic prisms, with an angle of $1: 0^{\prime} 10^{\circ}$ between its secondary prismatic planes. Color pale leek-green or liver brown. Streak unculored. Lustre vitreous to subadamantine. Subtransparent to nearly opaque. $H=3 \cdot 5-4$. G. $=3 \cdot 1-3 \cdot 3$. A hydrous arsenate of iron sesquioxide, containing 50 per cent. of arsenic pentoxide. From Saxony, Carinthia, Cornwall, and Brazil; and minute crystals near Edenville, N. Y., with arsenical pyrites. The name of this speecies is from the Greek shorodom, garlic, alluding to the odor before the blowpipe. Iron sinter is an amorphous form of the same minerul.

Arscniosiderite is another iron arsenate.
Siderite. - Spathic Iron. Iron Carbenate.
Rhombohedral. In rhombohedrons with easy cleavage parallel to a rhombohedron of $107^{\circ}$. Faces often curved. Usually massive, with a foliated structure, somewhat curving. Sometimes in globular concretions or implanted globules.

Color light grayish to brown; often dark brownish-red. It becomes nearly black on ex-

posure. Streak uncolored. Lustre pearly to vitreous. Translucent to nearly opaque. II. $=3-4 \cdot 5$. G. $=3 \cdot 7-3 \cdot 9$.

Composition. $\mathrm{Fe} \mathrm{O}_{3} \mathrm{C}=$ Carbon dioxide $37 \cdot 9$, iron protoxide $0 \gtrsim \cdot 1=100$. Often contains some manganese oxide or magnesia, and lime replacing part of the iron protoxide. Before the blowpipe it blackens and becomes magnetic ; but alone it is infusible. Dissolves in heated hydrochloric acid with effervescence.

The ordinary crystallized or foliated raricty is called spathic or sparry iron, because the mineral has the aspect of a spar. The globular concretions found in some amygdaloidal rocks have been called spherosiderite because of its spheroidal forms. An argillaccous varicty occurring in nod. mlar furms is often called clay iron stone, and is abundant in coal measures.

Diff. This mineral cleaves like calcite and dolomite, but it has a much higher specific gravity. It readily becomes magnetic before the blownipe. Heated in a closed glass tabe it gives off carbon dioxide, and becomes maruetic. This test distinguishes it from other iron ores.

Obs. Spathic iron occurs in rocks of varions ages, and often accompanies metallic ores. The largest deposits are in gneiss and mica sehist, and clay slate. It is also abondant in the coal formation principally in the form of clay iron stone. In Styria and Carinthia, it is very ahondant in gneiss, and in the IIartz it occurs in graywacke. Cornwall, Alstonmoor, and Deronshire are English localitios.

A rein of considerable extent occurs at Rochury, near Now Milford, Conn., in quartz, traversing greiss; at Plymonth, Vt., and Sterling, Mass., it is also abundant. It occurs also at Monroe, Conn.; in New York State, in Antwerp, Jefferson County, and in Hermon, St. Lawrence County. The argillaceous carbonate in nodules and beds, is very abundant in the coal regions of Pennsylvania and the West.

This ore is employed extensively for the manufac'ure of iron and stecl.

Mcsitite is an iron-and-magnesium carbonate. Ankerite contains in addition a large percentage of calcium. Like siderite in crystallization and cleavage.

Qeneral Remarks.-The metal iron has been known from the most remote historical period, but was little used until the last conturies before the Christian era. Bronze, an alloy of copper and tin, was the almost universal substitute, for cutting instruments as well as weapons
of war, among the ancient Egyptians and earlier Greeks; and even among the Romans (as proved by the relics from Pompeii), and also throughout Europe, it continued long to be extensively employed for these purposes.
The Chalybes, bordering on the Black Sea, were workers in iron and steel at an early period; and near tho year 500 B.C., this metal was introduced from that region ints Creece, so as to become common for weapons of war. From this source we have the expression chulybeate applied to certain substances or waters containing iron.
The iron mines of Spain have also been known from a remote epoch, and it is supposed that they have been worked "at least ever since the times of the later Jewish kings; first by the Tyrians, next by the Carthaginians, then by the Romans, and lastly by the natives of the country." These mines are mostly contained in the present provinces of New Castile and Aragon. Elba was another region of ancient works, "inexhaustible in its iron," as Pliny states, who enters somewhat fully into the modes of manufacture. The mines are said to have yielded iron since the time of Alexander of Macedon. The ore beds of Styria in Lower Austria, wero also a sourco of iron to the Romans.

The ores from which the iron of commerer is obtained, are the spathic iron or carbonate, magnetic iron, hematite or specular iron, limonite or "brown hematite," and bog iron ore. In England, the principal ore used is an argillacenus carbonate of iron, culled eften clay iron stone, found in nodules and layers in the ceal measures. It consists of carbonate of iron, with some clay, and externally has an carthy, stony look, with little indication of the iron it contains except in its weight. It yields from 20 to 3 3 per cent. of cast iron. The coal hasin of South Wales, and the counties of Stafford, Sulop, York, and Derby, yield by far the greater part of the English iron. Brown hematite is also extensively worked. In Sweden and Norwar, at the fumous works of Dannemora and Arendal, the ore is the magnetic iron ore, and is nearly freo from impurities as it is quarricd out. It yields 50 to 00 per cent of iron. The same ore is worked in Russia, where it abounds in the Urals. The Elba ore is the specular iron. In Germany, Styria, and Carinthia, extensive beds of the spathic iron are worked. The bug ore is largely reduced in Prussia.

In the United Statisg, all these different ores are worked. The localities are olrcady mentioned. The magnetic ore is reduced in New England, New 'Oork, Northern New Jersey, and sparingly in Pennsylvania, and other States. Limonite, or brown hematite, is largely worked along Western New England and Eastern New York, in Pemnsylvania, and many States South and West. The earthy argillaceous cirbonate like that of England, and the hydrate, are found with the coal deposits, and are a soure of much iron.
The amount of iron manufactured in the world in the rear $18 \% 3$ was $14,885,488$ tons, of which Great Britain produced $6,566,000$ tons, United States, $2,561,000$ tons, Germany 1,665,000 tons, France 1,381,090 tons, Belgium ( 633,000 tons, Austria with Hungary 425,000 tons, Russia 354,000 tons, Sweden 322,000 tons, Luxembourg 300,000 tons.

## MANGANESE.

The common ores of manganese are the oxides, the carbonate, and the silicates. Thero are also sulphides, an arsenide, and phosphate. They have a specific gravity below $5 \cdot 2$.

## Manganese Sulphides and Arsenide.

Alabandite or Mranganblende. A manganese sulphide MnS , of an iron-black color, green streak, submetallic lustre. H.-8.5-4. G. $=$ $3 \cdot 9-4 \cdot 0$. (rystals, cubes and regular octahedrons. From the gold mines of Nagyag, in Transylvania.

Haucritc. A sulphide, MnS:, containing twice the proportion of sulphur in the last. Color reddish brown and brownish black, resembling blende. H. $=4$. G. $-3 \cdot 46$. From Hungary.

Kuncite is a manganese arsenide, of a grayish-white color, and metallic lustre, which gives off alliaceous fumes. G.:-5.55. From Saxony.

## Pyrolusite.--Manganese Dioxide.

Trimetric. In small rectangular prisms, more or less moditied. $\quad I \wedge I=93^{\circ} 40^{\prime}$. Sometimes
 fibrous and radiated or divergent. Often massive and in reniform coatings.

Color iron-black; streak black, nonmetallic. $\quad \mathrm{H}=2-2.5 \quad(\mathrm{i}=48$.

Composition. $\mathrm{MnO}_{2}=$ Manganese 63. $\because$, oxygen $36 \cdot 8=100$. A minute portion of it imparts to a borax bead a deep amethystine color while hot, which becomes red-brown on cooling. It yiclds no water in a matrass.

Diff. Differs from psilomelane hy its inferior hardness, and from ores of iron by the violet glass with borax.

Obs. This ore is extensively worked in Thuringia, Moravia, and Prussia. It is common in Devonshire and Somersetshire, in England, and in Aberdeenshire. In the United States it is associated with the following species in Vermont, at Bemnington, Brandon, Monkton, Chittenden, and Irasburg; it occurs also in Maine, at Conway, and Plainfield in Massachusetts : at Salisbury and Kent, in Conn., on hematite ; on Red Island, in the Bay of San Francisco; at Pictou and Walton, Nova Scotia; near Bathurst, in New Brunswick.

The name pyrolusite is from the Greek pur, fire, and luo, to wash, and alludes to its property of discharging the brown and green tints of glass, for which it is extensively used.
Besides the use just alluded to, this ore is extensively employed for bleaching, and for affording the gas oxygen to the chemist.

Hausmannite. A manganese oxide, $2 \mathrm{MnO}+\mathrm{Mn}_{2}$, which contains 721 per cent. of manganese, when pure. Brownish black and submetallic, occurring massive and in square octahedrons. H. $=\bar{j}-5 \%$. $\mathrm{G} .=4.7$. From Thuringia and Alsatia. Hetarolite is a zinc-hausmannite, from Sterling Hill, N. J.

Braunite. An oxide of manganese, containing 69 per cent. of manganese when pure. Color and streak dark brownish-black, and lustre submetallic. Occurs in square netahedrons and massive. II. $=6-6.5$. G. $=4 \cdot 8$. From Piedmont and Thuringia.

Manganite. A hydrous sesquioxide of manganese. Occurs massive and in rhombic prisms. Color steel-black to iron-black. H. $==4-45$. G. $=4$ 3-4 4. From the Hartz, Bohemia, Saxony, and Aberdeenshire. It is found at several points in New Brunswick and Nova Scotia.

## Psilomelane.

Massive and botryoidal, Color hlack or greenish-black. Streak reddish or brownish-black, shining. $\mathrm{H}=\mathrm{m}-6 . \mathrm{X}_{\mathrm{a}}=$ 4-4.4.

Composition. Essentially manganese dioxide with a little water, and also some baryta or potassa. The compound is somewhat varying in its constitution. Before the blowpipe like pyrolusite, exeept that it affords water.

Obs. This is an abundant ore, and is associated usually with the pyrolusite. It occurs at the different, localities mentioned under pyrolusite, and the two are oftem in alternating layers; it has been considered an impure variety of the pyrolusite. The name is from the (ireek prilos, smooth or naked, and melas, black.

Pyrorhroite. Hydrous manganese protoxide, of white color. From Sweden. MnO, His.

Pclagite. The manganese nodules found in many regions over the bottom of the ocean. Affords, according to an adalysis, about 40 per cent. of $\mathrm{MnO}_{3}, 27 \mathrm{HeO}_{3}, 13$ of water lost at a red hiat, along with 14 per cent. of silica and 4 of alumina; 24.5 per cent. of water were lost below $100^{\circ} \mathrm{C}$. Probably a mixture.

Chalcophanite. A hydrons oxide of manganese and znac, in rhombohedral crystals and stalactites; from Sterling Hill, N. J.

## Wad.-Bog Manganese.

Massive, reniform or earthy ; also in coatings and dendritic delineations. Color and streak black or brownish black. Lustre dull, earthy. II. =1-6. G. $=3-4$. Soils the fingers.

Composition. Consists of manganese dioxide, in varying proportions, from 30 to $\% 0$ per cent., mechancally mixed with more or less of iron sesquioxide, 10 to 25 per cent. of water, and often several per cent. of oxide of cobalt or copper. It is formed in low places from the decompusition of minerals containing manganese. Gives off much water when heated, and affords a violet glass with borax.

Obs. Wad is abundant in Columbia and Dnichess counties, N. Y., at Austerlitz, Canaan Centre, and elsewhere; also at llue Mill Bay, Dover. and other places in Mane; at Nelson, Gilmanton, and Grafton, N. H.; and in many other parts of the country.

It may be employed like the preceding in bleaching, but is too impure to afford good oxygen. It may also be used for umber paint.

Lampadite, or Cupreous Manganese. A wad containing 4 to 18 per cent. of copper oxide.

## Triphylite.

Trimetric. In rhombic crystals, massive. Color greenish gray to bluish gray, but often brownish black externally from the oxidation of the manganese present. Sireak grayish white. Lustre subresinous. II. $=5$. $\mathrm{G} .=3 \cdot 54-3 \cdot 6$.

Composition. $\left(\frac{1}{4} \mathrm{li}_{2} \frac{3}{4} \mathrm{R}\right)_{3} \mathrm{O}_{8} \mathrm{P}_{2}$, in which R stamts for Fe and Mn. A Bodenmais specimen afforded Phosphorus pentoxide $44 \cdot 19$, iron protoxide $38 \cdot 21$, manginese protoxide $5 \cdot(i 3$, magnesia $2 \cdot 39$, lime $0 \cdot \%$, lithia $7 \cdot 69$, soda $0 \cdot 74$, potash 0.04 , silica $0.40=100 \cdot 0$. B.B. fuses very easily, coloring the flame a beautiful red, in streaks, with a pale bluishgreen on the exterior of the flame. Soluble in hyilrochloric acta.

Obs. Found at Rabenstein in Bavaria; in Finland; at Norwich, Mass.; Grafton, N. M.

Lithioplilite. A salmon-colored manganese-lithium phosphate, allied in composition to triphylite, but containing very littlo iron. From Redding (near Branchville Depot), Conu.

## Triplite.

Trimetric. Usually massive, with clearage in three directions. Color blackish brown. Streak yellowish gray. Lustre resinous ; nearly or quite opaque. Il. $=5-5 \%$. $4 .=$ 3•4-3.8.

Composition. ( $\mathrm{Mn}, \mathrm{Fe}_{3} \mathrm{O}_{8} \mathrm{P}_{2}+\mathrm{RF}_{2}$, affording about 30 per cent. of manganese protoxide, 8 of fluorine. Fuses easily to a black magnetic globule. B.B. imparts a violet color to the hot borax bead. Dissolves in hydrochloric acid.

Obs. From Limoges in France. Rather abundant at Washington, Comn, and rparingly found at Sterling, Mass.
Ilctcrosite, Alluaudite, Pscudotriplite, are regarded as resnlts of alteration, either of triphyline or of triplite.

Iriplnidite. A manganese-iron phosphate like triplite, but having the fluorine replaced by the elements of water. From Redding, Conn.

Dickinsonite. An oil-green to olive-greeu manganese-iron-calcium phosphate. From Redding, Conn.

Rcddingitc. A rose-pink hydrous manganese-iron phosphate. $\mathrm{Mn}_{3}$ $\mathrm{O}_{\mathrm{r}} \mathrm{P}_{2}+3$ act, isomorphous with scorodite and strengite. Redding, Ct.
Fairjieldite, hydrous manganese-calcium phosphate. lbid.
Hureaulite. liset-colored to brownish-orange hydruus manganeseiron phosphate. From Hurcaux, Franco.

## Rhodochrosite.-Manganese Carbonate.

Phombohedral. $\quad I \wedge R=166^{\circ} 51^{\prime}$; like calcite in having three easy clearages, and in lustre. Color rose-red. $\mathrm{H} .=3 \cdot 5-4 \cdot 5 . \quad(\mathrm{r} .=3 \cdot 4-3 \cdot \%$.

Composition. $\mathrm{MnO}_{3}(=$ Carbonic acid $38 \%$, manganese protoxide $61 \cdot 4=100$. Part of the manganese often replaced by calcinm, magnesium or iron.

Obs. From Saxony, Transvlvania, the Ilartz, Ireland; Mine Hill, New Jersey ; Reddagr, Conn.; Austin, Nevada; l'lacentia Bay, Newfoundland.

Rhodonite. A mangancse silicate. See p. 247.
General Remarks. Manganese is never used in the arts in the pure state ; but as an oxide it is largely employed in bleaching. The impritance of the ore for this purpose depends on the oxygen it contains, and the facility with which this gas is given up. As the ores are often impure it is important to ascertain their value in this respect. This is most readily done by heating gently the pulverized ore with hydrochloric acid, and ascertaining the amount of chlorine given off. The chlorine may be made to pass into milk of lime, to form a chloride, and the value of the chloride then tested according to the usual modes. The amount of chlorino derived from a given quantity
of muriatic acid depends not only on the amount of oxygen in the ore, but also on the presence or absence of baryta and such other carths as may combine with this acid. The binoxide of manganese, when pure, affords 18 parts by weight of chlorine, to 22 parts of the oxide ; or $23 \frac{1}{5}$ cubic inches of gas from 22 grains of the oxide. The best ore should give about three-fourths its weight of chlorine, or about 7,000 cubic inches to the pound avoirdupois.
Iron ores containing some manganese are used for making spiegeleisen, a hard highly crystallized pig-iron, containing a large amount of carbon and some manganese. A manganesian iron carbonate or siderite is thus used, and also the franklinite of New Jersey.
Manganese is also employed to give a violet color to glass. Tho sulphate and the chloride of manganese are used in calico printing. The sulphate gives a chocolate or bronze color.

## ALUMINUM.

The aluminum compounds among minerals include only one oxide-a sesquioxide $\mathrm{Al}_{3}$-hydrated oxides, fluorides, and, among tornaries, sulphates, phosphates, and numerous silicates. There are no sulphides or arsenides, and no carbonate, with a single imperfectly understood exception.

The silicates are described in the following section. Many aluminum compounds may be distinguished by means of a blowpipe experiment, as explained on page 87.

## Corundum.

Rhombohedral. $R \wedge R$ or $r \wedge r=86^{\circ} 4^{\prime}$. Clearage sometimes perfeet parallel with $O$, and sometimes par-
 allel to the rhombohedral faces. Usual in sixsided prisms, often with uneven surfaces, and sometimes so irregular that the form is scarcely traceable. Occurs also granular. Colors blue, and grayish-blue most common ; also red, yellow, brown, and nearly black; often bright. When polished on the surface $O$, a star of six rays, corresponding with the six-sided form of the prism, is sometimes seen within the crystal. Transparent to translucent. $\mathrm{H} .=9$, or next below the diamond. Exceedingly tough when compact. $\mathrm{G} .=3 \cdot 9-4 \cdot 16$.

Composition. $\mathrm{AlO}_{3}=0 \times \mathrm{yg}$ en $46 \cdot 8$, aluminum $53 \cdot 2=100$; pure alumina. B.B. remains unaltered both alone and with soda. The fine powder moistened with cobalt nitrate and ignited assumes a blue color.

Varieties. The name sapphire is usually restricted, in common language, to clear crystals of bright colors, used as gems; while dull, dingy-colored crystals and masses are called corundum, and the granular variety of bluish-gray and blackish colors containing much disseminated magnetite (whence its dark color) is called emery.
blue is the true sapphire color. When of other bright, tints, it receives other names; as oriental ruby, when red; oriental topaz, when yellow; oriental cmerald, when green; oriental ancthyst, when violet, and adamantine spar, when hair-brown. Crystals with a radiate chatoyant interior are often very beautiful, and are called asteria, or asteriated sapphire.

Diff. Distinguished readily by its hardness, exeeeding all species except the diamond, and scratching quartz crystals with great facility.

O6.s. The sapphire is often found loose in the soil. Metamorphic rocks, especially gneissoid mica schist, and granular limestone, appear to be its usual matrix. It is met with in several localises in the United States, bat seldom sufficiently fine for a gem. A blue rariety oecurs at Newton, N. J., in errstals sometimes several inches long ; huish and pink, at Warwick, N. Y.; white, bue, and reddish crystals at Amity, N. Y.; grayish, in laree rrystals, in Delaware and Chester comentios. Pemnsylvania; pale blue crystals have been found in bowlders at West Farms and Litchitield, Conn. It oceurs also in large quantities in North Carolina, where erystals are numerous though rarely fit for jewelry, and where one has been obtained weighing 31: pounds, and having a reddish color outside and hluish-gray within; also in Cherokee County, Georgia : in Los Angeles County, California. Emery is mined at chester, in Mass.

The principal forcign localities are as follows: hue, from Ceylon; the finest red from the Capelan Mountains in the kingdom of Ava, and smaller erystals from Saxony, Bohemia and Auverge ; cormoum, from the Carmatic, on the Malabar coast, and elsewhere in the East Indies; adamantine spar, from the Mahabr coast; emery, in large bowlders from near Smyrna, and also at Naxos and several of the Grecian islands.

The name sapphire is from the Greek word sappheiros. the name of a hlue gem. It is doubted whether it included the sapphire of the present day.

Next to the diamond, the sapphire in some of its varieties is the most costly of gems. The red sapphire is much more highly esteemed than those of other colors. A crystal of one, two or three carats is valued at the price of a diamond of the same size. They seldom exceed half an inch in their dimensions. Two splendid red crystals, as long as the little finger and about an inch in diameter, are said to be in the poserssion of the king of Arracan. The largest oriental ruby known was brought from China to Prince Gargarin, governor of Siberia; it afterward came into the possession of lrince Menzikoff, and constitutes now a jewel in the imperial crown of Russia.

Blue sapphires oceur of much larger size. According to Allan, Sir Abram Hume possessed a crystal which was three inches long. One of 9.51 carats is stated to have been found in Ava.

Corundum and emery are crushed to a powder of different degrees of fineness, and make the abrading and polishing material called in the shops emery. The iron oxide of true emery diminishes its harduess, and consequently its abrasive power ; pulverized corundum is more valuable and efficient in abrasion.

Diaspore. Hydrated aluminum of the formula $11 \mathrm{O}, \mathrm{H}_{2}=$ Water 149 , alumina $85 \cdot 1=100$. Csually found associated with corundum. Crystals usually thin and flattened. Color whitish, grayish, pinkish, etc. Very brittIe Translucent. H. 6\%-7. G. 3.0 . From the Urals; Schemnitz; Chester, Mass.; C'hester County, Pa.; North Carolina.

Gibbsite (Hydraryillife). Hydrated alumina, $\mathrm{Al}_{\mathrm{A}} \mathrm{H}_{6}=$ water $34 \cdot 5$, alumina $65 \%=100$. Occurs in hexagonal crystals ; more commonly in stalactitic and mammillary forms, with smooth surface, looking like chalcedony. Color white, grayish und greenish-white; trauslucent, sometimes transparent when in crystak. $H=25-35 ; \mathrm{G}=2.3-2.4$. Near Slatoust in the Ural ; in Asia Minor ; on corundum at Unionville, Pa.; at Richmond, Mass. in stalactitic forms ; in Orange ('ounty, N. Y.
Hydrotalicite (Volkncrite, Houghite). A soft pearly mineral, containing alumina, magnesia, and water. Accompanies spinel, and sometimes a result of the alteration of spinel crystals. Occurs near Slatoust; at Snarum, Norway ; near Oxbow in Rossie, Sit. Lawrence County, N. Y. (the varicty Houghite).

## Spinel.

Isometric. In octahedrons, more or less modified. Figure 4 represents a twin crystal. Occurs only in crystals; cleavage octahedral, but difficult.

Color red, passing into blue, green, yellow, brown, and
hlack. The red shades often transparent and bright; the dark shades usually opaque. Lustre vitreous. $\mathrm{I} .=8$. $\mathrm{G} .=3 \cdot 5-4 \cdot 1$.


Compnsition. $\mathrm{MgAl} \mathrm{O}_{4}=\mathrm{Mg} \mathrm{O}+\mathrm{AlO}_{3}=$ Alumina ${ }^{\prime} 2$, magnosia ${ }_{2}=100$. The alummum is sometimes replaced in part by iron, and the magnesium often in part by iron, calcium, manganese and zinc. Infusible; insoluble in acids.

Vabibtifs. The following varieties of this species have received distmet nanes: the scarlet or bright red crystals. spinel ruby, the rose-red, baldes-ruby; the orange-red, rubicelle; the violet, almondine-ruby; the green, chlorospiut; while the black varieties are called pleonnste. Plenmaste erystals contain sometimes 8 to 20 per cent. of oxide of iron. Picotite is a varicty containing 7 per cent. of chromium oxide.

Diff. The form of the crystals and their hardness distinguish the species. Garnct is fusible. Magnetite is attracted by the magnet. Zircon has a higher specitic gravity and is not so hard. The red crystals often resemble the true ruby (red corundum), but the latter are never in octahedrons.

Obs. Occurs in granular limestone ; also in meiss and volcanie rocks. At momerous phaces in the adjoining counties of Sussex in New Jersey, and Orange county, of various
colors from red to brown and black ; especially at Franklin, Newton and Sparta, in the former. and in Warwick, Amity and Edenville, in the latter. The crystals are octahedrons, and often grouped or disseminated singly in granular limestone. One erystal, found at Amity by I)r. Heron, weighs 49 pounds. The limestone quarries of Bolton, Boxborough, Chelmsford and Littleton, Mass., afford a few crystals.

Crystals of spinel are occasionally soft, having undergone a change of composition approaching steatite in all characters except form. They are true pseudomorples. They are met with in Sussex and (range counties. Other spinel pseudomorphs consist of hydrotalcite (see preceding page).

I'ses. The fine colored spincls are much used as gems. The red is the common ruby of jewelry, the oriental rubies being sapphire.

Gaknite is a spinel in which zinc takes the place of part or all of the magnesium; when all, it is called Automolite. ('olor dark green or greenish black. H. $=7 \cdot 5-8 . \quad$ G. $=-4-4 \%$. Whez fused with sufficient soda, B.B. on coal a white coat of zine oxide is deposited, which is yellow when hot. B.B. infusible. At Franklin. N. J., and at the Canton mine in Georgia. Occurs in granite at Laddan with beryl, chrysoberyl, garnet, etc. In Sweden, near Fahlun, in talcose slate.

Dysluite. A variety of gahnite containing oxide of manganese. Color yellowish or grayish-brown. $\mathrm{H}=75-8 . \quad \mathrm{G}=45 \mathrm{~F} . \quad$ (impoaition, Alumina $30 \%$, zinc oxide 16.8 , iron sesquioxide 41.9 , manganese protoxide 7\%, silica 3, water 04. From Sterling, N. J., with franklinite and troostile.

Kreittonite is a ginc-iron gahnite.
Hercivite is a spinel affording on analssis alumina and iron protoxide, with only 29 per cent. of magnesia.

## Chrysoberyl.

Trimetric. $I \wedge I=129^{\circ} 38^{\prime}$. Nlso in compound crystals, as in fig. 7. Crystals sometimes thick ; often tabular.

Color bright green, from a light shade to emerald-green; rarely rasplery or columbine-red by transmitterd light. Streak uncolored. Lastre vitreous. 'Tramsparent to translucent. $\quad I I=8 \% . \quad G .=35-3 \cdot 8$.

Composition. BeAl $\mathrm{O}_{4}=$ Alumina $80^{\circ}$, glucina $19 \cdot 8=100$. A little iron is sometimes present. B.B. infusible and unaltered

Alexandrite is an emerald-green variety from the Urals, colored by chrome, bearing the same relation to ordinary chrysoberyl as emerald to beryl. Fig. 7 is of this variety.

Diff. Near beryl, but distinct in not being regularly hexagonal in erystallization.

Obs. Chrysoberyl occurs in the United States in granite at Haldam. Conn., and Greenfield, near Saratoga, N. Y., associated with beryl, garnet, etc.; in Norway, Maine.



The name chrysoberyl is from the Greek chrysos, golden, and beryllow, heryl.
The irystals are seldom sufficiently pellucid and clear from flaws to be valued in jewelry; but when of fine quality, it forms a beantiful gen, and is often opalescent.

## Fluorides of Aluminum.

Cryolite. In snow-white masses, having rectangular cleavages, and remarkable for melting easily in the flame of a candle, to which its name (from the Greck liruos, ift) alludes. H. $=2 \mathrm{j} . \quad$ ( $i=2.95$. It is a sodium-aluminum flumide. From Greenland.

Ohiolite and Chodncfitite are near crvolite in composition and characters. Arksutite, Gearksutite, Pachnolitc, Thomsenolite are related fluorine compounds which occur associated with the Greenland cryolite From siberia.

Fluclitr: From Connwall, in minute white rhombic octahedrons. Contains fluorine and aluminum.

Alunogen.-Ilydrous Aluminum Sulphate.
In silky efflorescences, and crusts of a white color, having a taste like common alum. $\quad \mathrm{H} .=1 \cdot 5-2 . \quad(\mathrm{X} .=1 \cdot(\mathrm{f}-1 \cdot 8$.

Composition. Al $O_{12} \mathrm{~S}_{3}+18 \mathrm{aq}=$ Sulphur trioxide 360 , alumina $10 \cdot 4$, water $48 \cdot 6=100$.

Obs. A common efflorescence in solfataras of voleanic regions, and aks often oceurring in shales of coal regions and other rocks contaimng pyrite; the oxidation of the pyrite-an iron sulphide-affords sulphuric acid, which acid combines with the alumina of the shale.

Alums. Frequently the sulphuric acid resulting from the oxidation of a sulphide, or in some other way, combines also with the iron, magnesia or potash or soda of the shale or other rock, as well as the alumina, and so makes other kinds of aluminum sulphate.

Combining thus with potash it produces common alum called Felinite or potash alum, whose formula is $\mathrm{K}_{2} \mathrm{Al}_{3} \mathrm{O}_{24} \mathrm{~S}_{4}+18$ aq; with ammonia, it forms an ammonia-alum, named '1schermigite; with iron, iron-alum, called Halotrichitc; with soda, a soda-alum, Mcntezitc; with magnesia a magnesia-alum, I'ickeringite; with manganese, a manganese-alum, Apjohnite and Bosjemanite. The formulas of these alums are alike in atomic proportions, excepting in the amount of water, which varies from 18 aq to 24 aq .

Shale containing alunogen or any of the alums is often called alum shale. Such rocks. whether shales or of other kinds, are often quarried and lixiviated for the alum they contain or will afford. The rock is first slowly heated after piling it in heaps, in order to decompose the remaining pyrites and transfer the sulphuric acid of any iron sulphate to the alumina and thus produce the largest amount possible of aluminum sulphate. It is next liviviated in stono cisterns. The lye containing this sulplate is afterwards concentrated by evaporation, and then the requisite proportion of potassium in the form of the sulphate or chloride is added to the hot solution. On cooling, the alum crystallizes out, and is afterwards washed and re-crystallized. Tho mother liquor left after the precipitation is revaporated to obtain tho remaining alum held in solution. This process is carried on extensively in Germany, France, at Whitby in Yorkshire, Murlett and Campsie, near Glasgow, in Scotland. Cape Sable in Maryland affords large quantities of alum annually. Tho slates of coal beds are often used to advantage in this manafacture, owing to the decomposing pyrites present. At Whitby, 1:30 tons of calcined schist give one ton of alum. In France, ammoniacal salts are used instcad of potash, and an ammonia alum is formed.

Alum is also manufactured from cryolite (see p. 19\%), which is obtained from Gireenland.

## Alunite--Alum Stone.

Rhombohedral, with perfect basal clearage. Also massive. Color white, grayish, or reddish. Lustre of crystals vitreous, or a little pearly on the basal plane. Tramsparent to translucent. $\quad \mathrm{H} .=4 . \quad \mathrm{G}=2 \cdot 58-2 \cdot \pi 5$.

Composition. $\mathrm{K}_{2}$ Al $\mathrm{O}_{29} \mathrm{~S}_{4}+6 \mathrm{a}_{1}=$ Suphoric trinxide $38 \cdot \frac{-}{9}$, alumina $37 \cdot 1$, potash $11 \cdot 4$, water $13 \cdot 0=100$. I3. J. decrepitates and is infusible; srives reaction for sulphur.

Diff. Distinguished by its infusibility, in connection with its complete solubility in sulphuric acid without forming a

Öbs. Found in rocks of volcanic origin at Tolfa, near Home ; and also at Beregh and elsewhere in Hungury.

When it is calcined the sulphates becomo soluble, and tho
alum is dissolved ont. On evaporation the alum crystallizes from the fluid in cubic crystals. This is called Roman alum, and is highly valued by dyers, because, although the crystals are colored red by iron oxide, no iron is chemically combined with the salt as is usual in common alum.

Aluminite (Websterite). Another hydrous aluminum sulphate, in compact reniform masses, and tasteless. From New Haven, in Sussex; Epernay, in France ; and Halle, in Prussia.
Lexigite is a potassium-aluminum sulphate, containing half the water of potash alum.

## Amblygonite.-Lithium-Aluminum Phosphate.

Triclinic, with cleavages unequal in two directions, making an angle with one another of $104 \pm^{\circ}$. Lustre vitreous to pearly and greasy. Color pale mountain-green, or seagreen to white. Iranslucent to subtransparent. II. $=0$. G. $=3-3 \cdot 11$.

Composituon. A lithium-aluminum phosphate, $\mathrm{AlO}_{8} \mathrm{P}_{2}+$ 1 $\frac{1}{2}(\mathrm{~L}, \mathrm{~N} \cdot \mathrm{a}) \mathrm{F}$. 13.B. fuses very caslly with intumescence, coloring the flame yellowish red to rich carmine-red, owing to the lithia present, and traces of green owing to the phosphoric acid. Gives the raction also for fluorinc.

Olis. Occurs in Saxony and Norway.
$H_{4}$ bronite $1 s$ a closely related mineral from Hebron and Mount Mica in Maine, and from Redding in connecticut.

Herderite is supposed to be an anhydrous calcium-aluminum phos. phate with fluorine.

Durangite. An anhydrous arsenate of an orange-red color, contaiuing aluminum, sodiun, iron, and some manganess, with over 7 per cent. of fluorinc. From Durango, Mesico, where it occurs with cassiterite or tin ore.

## Lazulite.

Monoclinic. In crystals and also massive, of an azure-blue color. $11 .=5-6$. $\quad$ i $=3 \cdot 05 \%$.

Compostion. RAl Og $\mathrm{P}_{4}+\mathrm{aq}_{4}=$ Phosphorus pentoxide $46 \cdot 8$, alumina $34 \cdot 0$, magnesia $13 \%$, water $60=100$. B.B. in the closed tube whitens and yields water : with cohalt solation the color is restored; in the forerps whitens, swells, cracks, and falls to pieces without fasion, coloring the flame bluishgreen.

Obs. From Salzburg, Styria; Wermland, Sweden; Crowder Mount, Lincoln County, N. C. ; and on Graves Mountain, Lincoln County, Georgia.

Variscite (Peganite, Callainite) is another hydrous aluminum phosphate; it is of a light green color, of various shades, to deep emeraldgreen. From Montgromery County, Arkansas, and from Colorado; also from Messbach, in Saxon Voigtland. Fischerite is a related mineral.

## Turquois.

In opaque reniform masses without clearage; of a hluishgreen color, and somewhat waxy lustre. $\mathrm{H} .=6 . \quad \mathrm{G} \cdot=2 \cdot 6$

Composition. Phosphorus pentoxide $32 \cdot 6$, alumina $4 f \cdot 9$, water $20: 5=100$. B.13. infusible, but becomes brown and colors the flame green ; soluble in hydrochloric acid ; moistened with the acid it gives a momentary bluish green color to the flame, owing to the copper that it contains.

Diff. Distinguished from bluish-green feldspar, which it resembles, by its infusibility and the reactions for phosphorus.

Obs. Turquois is brought from a mountainous district in Persia, not far from Nichabour; and. according to Agaphi, occurs in veins that traverse the mountain in every direction.
The Callais of Pliny was probably turquois. Pliny, in his description of it, mentions the fable that it was found in Asia, projecting from the surface of inaccessible rocks, whence it was ohtained by means of slings.

Turguois receives a fine polish and is highly esteemed as a gem. In Persia it is much admired, and the lersian king is said to retain for himself all the large and more finely tinted specmens. The ofcidental or bone turguos, is fossil teeth or bones, colored with a little phowhite of iron. Green malachite is sometmes substituted for turquois, but it is of little hardness and has a different tint of color. The stone is so well imitated hy art as scarcely to bedetected except by chemical tests. The imitation is much solter than true turquois.
Childrenite. A hydrous phosphate containing aluminum, iron, with little manganese. Found in trimetric crystals in Devonshire and Cornwall; also at Hebron in Maine.
Eusphorite. Has the crystalline form and nearly the angles of childrenite, and contains the same constituents, but differs in being essentially a hydrous phosphate of manganese with little aron. From Redding, Connecticut.
Heneoodite is a hydrous aluminum phosphate from Cornwall, containing also copper.

## Wavellite.

Trimetric. Usually in small hemispheres a third or half an inch across, attached to the surface of rocks, and having a finely radiated structure within ; when broken off they leave a stellate circle on the rock. Sometimes in rhombic crystals.


Color white, green, or yellowish and brownish, with a somewhat pearly or resinous lustre. Sometimes gray or black. Translucent. $\mathrm{H} .=3 \cdot 5-4 . \quad \mathrm{T} .=2 \cdot 3$.

Composilion. $\mathrm{Al}_{3} \mathrm{O}_{19} \mathrm{P}_{4}+12 \mathrm{aq}=$ Phosphorus pentoxide 35•16. alumina $38 \cdot 10$, water $26 \% 4=100$. 1 to 2 per cent. of fluorine is often present, replacing the oxygen. B.B. whitens and swells, but docs not fuse. Colors the flame green, especially if previously moistened with sulphuric acid. Moistened with colalt nitrate, assumes a blue color after ignition ; gives much water in the closed glass tube.

Diff. Distinguished from the zeolites, some of which it resembles, by giving the reaction of phosphorus, and also by dissolving in acids without gelatinizing. Cacosene, to which it is atlied, becomes dark reddish-brown hefore the hlowpine: and does not give the blue with cobalt nitrate.

Obs. Oecurs at the slate quarries of York County, Pa., and also at Washington Mine, Davidson County, N. C.; at Magnet Cove, Ark. It was first discovered by 1)r. Wavel, in clay slate in Devonshire. Uccurs also in Bohemia and Bavaria.

## Zepharnvirhite is near wavellite.

Mellite or Honey stone. In square octahedrons, looking like a honeyvellow resin ; may be cut with a knife. It is an aluminum mellate. Found in Thuringia, Bohemia, Moravin, etc.

Darsonite. Hydrous aluminum-calcium carbonate, from a felsyte dike near Montreal.

CERIUM, TTTRRICM, ERBIUM, LANTHANTM, DIDYMIUM.
Known in nature in the condition of floorides, tantalates, columbates, phosphates, or carbonates, and also as constituents in several silicates.

## Yttrocerite.

Massive, of a violet-blue color, somewhat resembling a
purple fluor-spar; sometimes reddish-brown. Opaque. Lustre glistming. $H=4-5 . \quad G .=3 \cdot 4-3 \cdot 5$.

Composition. Fluorine $25 \cdot 1$, lime $4 \%$, cerium protoside $18^{\circ} 2$, and yttria $9 \cdot 1$. Infusible alone before the blowpipe.

Ols. From Finbo and Broddbo, near Fahlun, in Sweden, with albite and topaz in quarts. Also from Mt. Mica, Maine ; Massachusetts, probably in Worcester C'ounty; and from Amity, Orange County, N.Y.
Fluocrite and Fluocerine aro other fluorides containing cerium, from Sweden.

## Samarslite.

Trimetric. $I \wedge I=122^{\circ} 46^{\prime}$. Usually massire. without cleavage, with a velvet-black color and shining submetallic lustre. Streak dark-reddish brown. Opaque. II. $=5 . j-6$. $\mathrm{G} .=5 \cdot 6-5 \cdot 8$.

Compnsition. Analyses of the Amcrican afforl columbic and tantalic pentoxide, with sesquioxide's of yttrium (12-15 per cent.), cerium, iron, and oxide of uranium. In the closed tube decrepitates and glows. B.B. fuses on the edges to a black class. With salt of phosphorus in both flames, an emerald-green bead.

Obs. Occurs at Miask, in the Ural ; also in masses, sometimes weighing many pounds, at the Mica mines of Western North Carolina, along with columbite.
Nohlite is near samarskite, but contains 4 . 82 of water.
Fergusorite. A hydrous columbate of ytrium. crininm, ccrium. Color brownish black; lustre dull, but brilliantly vitreous on a surface of fracture. B.B. infusible, but loses its culor. From Sweden, Cape Farewell, Qreenland, and Ruckport, Mass.
Korfuelite is near fergusonite.
Yttro-tantrite. A tantalate and columbate of yttrium, erbiam, and iron. The different varieties are the black, the yellow, and brown or dark colored. They are infusible. Frum Ytterby, Sweden, and at Broddho and Finbo, near Fahlun.
Euxenitc. A columbate and tantalate of yttrinm, uraninm, erbium, and cerium. Massive. Color brownish black. Streak reddish brown. B.B infusible. From Norway; also from N. Carolina

Sopylite. A columbate and tantalate of erbium and vttrium, resembling fergusonite in aspect. From Amherst County, Va.

Pyrorhlerce, Mievolite, Divanalyte, under Calciom, p. 214.
Awchynite. In crystals, black to brownish yellow : lustre resinous to submetallic ; streak gray to yellowish brown or hack. H. - 5 -6. G $-4.9-51$. A columbate and titanate of rerium, thorium, and lanthanum. From Mask, in the Urals, in frldspar with mica and zircon.

Polymignite and Polycrase. Related to æschynite.

Rogersite. A hydrous columbate of yttria, in whitish crusts, on samarskite. From N. Carolina

## Monazite.

Monoclinic. In modified oblique rhombic prisms; $I \wedge I$ $=933^{\circ} 10^{\prime}$. Perfect and brilliant basal cleavage. Observed only in small imbedded crystals.

Color brown, brownish red; subtransparent to nearly opaque. Lustre vitreous inclining to resinous. Brittle. $\mathrm{H} .=5 . \quad \mathrm{G} .=4 \cdot 8-5 \cdot 1$.

Composition. A phosphate containing ccrium, lanthanum, yttrium, didymium and thorium, with also a litile tin, manganese, and lime. B.B. it colors the flame green when moistened with sulphuric acid and heated. Diflicultly soluble in acids.

Diff: The brilliant easy transverse clearage distinguishes monazite from sphene.

Obs. Oeeurs near Slatoust, Russia. In the United States it is found in small brown crystals, disseminated through a mica slate at Norwich, Conn. ; also at Chester, Conn., and Yorktown, Westchester County, N. Y.

Cryptolitc. A cerium phosphate in minute prisms (apparently six. sided), found with the apatite of Arendal, Norway. Color pale wineyellow. G. $=4.6$.

Churchite. A phosphate of cerium, didymium and calcium ; from Cornwall.

Xcmutime. An yttrium phosphate having a yellowish-brown color, pale brown streak, opaque, and resinous in lustre. Crystals squaro prisms, with perfect lateral cleavage. $H=4-\pi . \quad(\exists=4 \%$. Infusiblo alone before the blowpipe; insoluble in acids. From Lindesnacs, Norway; Ytterby, Sweden ; gold washings of Clarkesville, Ga., and McDowell County, N. C.

Parisite. Is a carbonato containing corium, lanthanum, and didymium, with fluorine. From New Granada.

Lanthanitc. Occurs in thin minute tables or scales of whitish or rellowish color, and is a hydrous lanthanum carbonate. From Bastnils, Sweden, and Saucon Valley in Lehigh C'ounty, Pa.

Tengerite. An yttrium carbonate. Found in thin coatings at Ytterby, Sweden.

Rhabrophane. A didymium and erhium phosphate; from Cornwall, with aphalerite (blende), which it resembles.

Rutherfordite. A blackish-brown vitreo-resinows mineral. From the gold mines of Rutherford County, N. C.
Allanite, Gadolinite, Kcilhauitc, and Tscheffkinite, are silicates containing either cerium or yttrium.

## MAGNESICM.

Magnesium occurs, in nature, as an oxide or hydrated oxide, and in the condition of sulphate, borate, nitrate, phosphate, carbonate and silicate.

The sulphates and nitrate of magnesia are soluble in water, and are distinguished by their bitter taste; the other native magnesian salts are insoluble. The presence of magnesia, when no metallic oxides are present, is indicated by a blowpipe experiment, explained on page $8 \%$.

Periclasite.-Periclase. Magnesium Oxide.
Isometric. In small grayish to dark-green imbodded crystals, with cubic cleavage. II. nearly $6 . \quad$ G. $=3 \cdot 6$. 4 .

Compusition. Mg O (or the same as for maynesia alba of the shops), with a little iron. B.B. infusible. Noluble in acids without efferrescence.

From Mount Somma, Vesuvius, Italy.

> Brucite.-Magnesium Hydrate.

Rhombohedral. In foliated hexagonal prisms and plates; structure thin foliated, and thin lamine casily separated and translacent ; flexible but not elastic. Also fibrous. Lustre pearly. Color white, often grayish or greenish. $\mathrm{IL}=2 \cdot \mathrm{j} . \quad(\mathrm{x} .=2 \cdot 35$.

Composition. $\mathrm{Mg} \mathrm{O}_{2} \mathrm{H}_{2}=$ Magnesia $69 \cdot 0$, water $31 \cdot 0=100$. B.B. infusible. but becomes opaque and alkaline. Soluble in herlrochloric acid without effervescence.

Ififf. It resembles tale and gypsum, but is soluhle in acils: it differs from heulandite and stalbite also by its infusibility.

Ods. Occurs in serpentine at Hoboken, N. J. ; in Richmond County, N. Y. ; in Dutchess County, N. Y., at Brewster's ; at Texas, in Pennsylvania; also at Swinaness, in Unst, one of the Shetland Isles.

The fibrous varety has been called nemalite; it resembles amianthus ; it occurs at Moboken.

A pearly crystalline, or earthy, white, hydrous carbonate of magnesia, from Hoboken, N. J., Texas, la, and elsewhere.

Sprnel contains oxygen and magnesium along with aluminum. See page 105. Magnesium is also present in some magnetite, a variety of which is called magnoferritc.

Chlormagnesite. A magnesium ohloride from Vesuvius.
Carnallite. A hydrous magnesium-potassium chloride.
Tachydrite. A hyaıus magnesium-calcium chloride.

## Epsomite.-Epsom Salt. Magnesium Sulphate.

Trimetric. $I \wedge I=90^{\circ} 34^{\prime}$. Cleavage perfect parallel with the shorter diagonal. Usually in fibrous crusts, or botryoidal masses, of a white color. Lustre vitreous to earthy. Very soluble, and taste bitter and saline.

Composition. $\mathrm{Mr} \mathrm{O}_{4} \mathrm{~S}+7 \mathrm{Fq}=$ Sulphur trioxide 32.5 , magnesia $16 \%$, water $51 \% 2=100$. Liquefies in its water of crystallization when heated. Gives much water which has an acid reaction, in the closed glass tube. B.B. on chareoal fuses, but finally gives an infusible mass that turns pink when moistened with cobalt nitrate and ignited.

Diff. The fine epicula-like crystallme grains of Epsom salt, as it appears in the shops, distinguish it from Glanher salt, which occurs usually in thick erystals.

Obs. The floors of the limestone caves of the West often contain Epsom salt in minute crystals mingled with the earth. In the Mammoth (ave, Ky., it adheres to the roof in loose masses like snowballs. It occurs as an efflorescence in the galleries of mines and elsewhere. The fine efllorescences suggested the old name hair-salt.

At Episom, in Surrey, England, it occurs dissolved in mineral springs, and from this place the salt derived the name it hears. It occurs at Sedlitz, Aragon, and other places in Europe ; also in the Cordilleras of Chili : and in a grotto in Southern Africa, where it forms a layer an inch and a half thick.

Its medical uses are well known. It is obtained for the arts from the bittern of sea-salt works, and quite largely from magnesian calcium carbonate, by decomposing it with sulphuric acid. The sulphuric acid takes the lime and magnesia, expelling the carbonic acid; and the sulphate of magnesium remaining in solution is poured off from the calcium sulphate, which is insoluble. It is then erystallized by evaporation.

Polyhalite. A brick-red saline mineral, with a weak bitter taste, occurring in masses which have a somewhat fibrous appearance. A hydrous calcium magnesium sulphate.
Kieserite. A hydrous magnesium sulphate ; from Stassfurt.
Picromeride. A hydrous potassium-magnesium sulphate; from Stassfurt.

A hydrous sodium-magnesium sulphate; from the salt mines of Ischl, and near Mendoza.

Loweite. A hydrous sodium magesium sulphate; from Ischl. Contains more sulphur trioxide than Blodite.

## Boracite.-Magnesium Borate.

Isometric. Clearage octahedral ; but only in traces.

1. Usual in cubes with only the alternate angles replaced: or having all replaced, but four of them different from the other four. The cristals are translucent and seldom more than a quarter of an inch
 through. Also massive. (iolor white or grayish ; somotimes yellowish or greenish. Lustre vitreons. II. $=7$ when in crystals, but softer when massive. $(\dot{i}=2.0 \%$. Becomes electric when heated, the opposite angles of the cube becoming of opposite poles.

Comproxitiom. $\mathrm{Mr}_{3} \mathrm{O}_{15} \mathrm{~B}_{8}+\frac{1}{2} \mathrm{Mg} \mathrm{Cl}_{2}=$ Boron trioxide 62.0, magnesia $31 \cdot 0$, chlorme $\gamma \cdot(0)=100$. B.B. fuses easily with intumescence coloring the flame green. The fused globule becomes crystalline on cooling. Dissolves in hydrochloric acid. and moistened with cobalt nitrate turns pink on ignitions.

Diff. Distinguished readily by its form, high hardness, and pyro-electric propertios.

Obs. Boracite 18 found only with gypsum and common salt. It occurs near Luncberg in Lower Saxony, and near Kiel in the adjoining duchy of Holstem, also at Stassfurth, Prussia.

Thodizita Resembles boracite in its crystals, but tinges the blowpipe flame deep red. It is supposed to be a lime-boracite. Occurs with tho red tourmaline of Siberia. Ludeigite. A magnesium-iron borate, fibrous and dark green to black.

Nzuïrlyite. A hydrous maguesiam borate, from Southeastern Hungary:

Waricickite. In rhombic prisms of $93^{\circ}$ to $94^{\circ}$, hair-brown to black with somelimes a copper-red tinge. A magnesium-titanium borate; from granular limestone of Edenville, N. Y.

Sussexite. A hydrous magnesium-manganese borate. Fibrous and pearly. G-3.42. from Mine Hill, Franklin Furnace, Sussex Co., N. J.

Nitromreqnesite. Occurs in white deliquescent efflorescences, having a bitter taste, associated with calcium nitrate, in limestone caverns. It is used, like its associate, in the manufacture of saltpetre.

Wignecritc. A magnesium fluo-phosphate, occurring in yellowish or
grayish obliqua rhombic prisms. Insoluble. H. $=5-5 \cdot 5 . \quad$ G. $=3 \cdot 1$. From Salaburg, Austria. Ljerulfine is near wagnerite.

IIcrnisite and Rossleritc are hydrous calcium arsenates.
Lïneburgite. A magnesium buro-phosphate, from Lüneburg.

## Magnesite.-Magnesium Carbonatc.

Rhombohedral. $R: R=107^{\circ} 29^{\prime}$. Clearage rhombohedral, perfect. Often massive, cither granular, or compact and porcelain-like, in tuberose forms; also fibrous.

Color white, yellowish or grayish-white, or brown. Lastre vitreons; fibrons varieties often silky. Transparent to opaque. $\mathrm{H}:=3-4 \cdot 5 . \quad \mathrm{G} .=3$.

Compnsition. $\mathrm{MgO} \mathrm{O}_{3} \mathrm{C}=$ (arbon dioxide $52 \cdot 4$, magnesia $476=100$. Infusible before the blowpipe. After ignition has an alkaline reaction. Nearly insoluble in cold dilute hydrochloric acid, but dissolves with effervescence in hot.

Diff. Resembles some varicties of calcite and dolomite; but from a concentrated solution no calcium sulphate is precipitated on alding sulphuric acid. The fibrous variety is distingnished from other fibrous minerals by its effervescence in hont acid, which shows it to be a carbonate.

Ubs. Marnesite is usnally associated with magnesian rocks, especially serpentine. At Hoboken, N. J., it oceurs in this rock in fibrous seams : similarly at Lymntield, Mass; and in Canada, at Bolton, imperfectly fibrous, traversing white limestone.

When abundant it is a convenient material for the manufacture of magnesium sulphate or Epsom salt, to make which, requires simply tratment with sulphuric acid.

Hydromagnesite. A hydrous magnesium carbonate. Occnrs with serpentine, at Hoboken, but more abundantly in Lancaster Co.. Pemu.

Dolomite. A magnesium und calcium carbonate. Sce page 219.

## CALCIUM.

Calcium exists in nature in the state of fluorite, and this is its only binary compound. It occurs in ternaries in the state of sulphate, borate, columbate, phosphate, arsenate, carbonate, titanate and silicate. The carbenate (calcite and limestone) is one of the three most abundant of minerals. The fluoride and sulphate, and some silicates, are also of very common occurrence.

With the exception of the calcium nitrate, none of the native salts of lime are soluble in water except in small proportions. They give no odor, and no metallic reaction before the blowpipe ; but they tinge the flame red, and many of them give up a jart of their acid constituent, and become caustic and react alkaline. The specific gravity is below $3 \cdot 2$, and hardness not above 5 .

## Fluorite.-Fluor Spar. Calcium Fluoride.

Isometric. Clearage octahedral, perfect. Commonly in crystals ; rarely fibrous ; often compact, coarse or tine granular. Figures 1 to 4 represent common forms.

4.


Colors usually bright: white, or some shade of light green, parple, or clear yollow are nost common; rarely rose-red and sky-blue; colors of massive ramieties often banded. Transparent, translucent or subtranslucent. $\mathrm{I}=4$. $\mathrm{G} .=3-3 \cdot 25$. Brittle.

Composition. $\mathrm{CaF}_{2}=$ Fluorine $48 \cdot 7$, calcium $513=100$. Phosphoresees when gently heated in the dark, affording light of different colors; in some varieties emerald-green; in others, purple, blue, rose-red, pink, or orance. B.B. decrepitates. and ultimately fuses to an enamel, which possesses an alkaline reaction ; pulverized and moistened with sulphuric acid, hydrofluoric acid gas is given off which corrodes glass. The name ('hlorophane has been given to the raricty that affords a bright green phophorescence.

Diff. In its bright colors, fluorite resembles some of the gems, but its softness and its easy octahedral clearage when crystallized at once distinguish it. Its strong phosphorescence is a striking characteristic; and also its affording
easily, with sulphuric acid and heat, a gas that corrodes glass.

Obs. Fluorite occurs in gneiss, mica schist, clay slate, limestone, and sparingly in beds of coal either in veins or occupying cavities, or as imbedded masses. It is the gangue in some Jead mines.

Cubic crystals of a greenish color, over a foot each way, have been obtained at Muscolonge Lake, St. Lawrence County, N. Y.; near Shawnectown on the Ohio, a beautiful purple fluor in grouped cubes of large size is obtained from limestone and the soil of the region ; at Westmoreland, N. H., at the Notch in the White Mountains, Blue IIill Bay, Maine, Putney, Vt., and Lockport, N. Y., are other localities. The chlorophane varicty is found with topaz at Trumbull, Conn.

In Derbyshire, England, flnor spar is abundant, and hence it has received the name of Derbyshire spar. It is a common mincral in the mining districts of Saxony.

Calcium fluorite also exists in the enamel of teeth, in bones and some other parts of animals ; also in certain parts of many plants; and by vegetable or animal decomposition it is afforded to the soil, to rocks, and also to coal beds in which it has been detected.

Massive fluor receives a high polish, and is worked into vases, candlesticks and various ornaments, in Derbyshire, England. Some of the varicties from this locality, consisting of rich purple shades banded with yellowish white, are very beantiful. The mineral is difficult to work because brittle. Fluor spar is also used for obtaining hydrofluorie acid, which is employed in etching. To etch glass, a picture, or whatever design it is desired to etch, is traced in the thin coating of wax with which the glass is first covered; a very small quantity of the liquid hydroflaoric acid is then washed over it ; on removing the wax, in a few minutes, the picture is found to be engraved on the glass. The same process is used for etching seals, and any siliccous stone will be attacked with equal facility. This application of fluor spar depends upou the strong affinity between fluorine and silicon. Fluor spar is also used as a flux to aid in reducing copper and other ores, and hence the name fluor.

## Gypsum.-Hydrous Calcium Sulphate.

Monoclinic. $\quad I \wedge I=143^{\circ} 42^{\prime} ; 2 i \wedge 2 i+111^{\circ} 42^{\prime}$. Figure 6 represents a common twin (or arrow-head) crystal. Oleav-

1. age parallel to $i-i$ very easy, affording thin pearly laminæ; parallel to 0 , imperfect, giving a vitreous surface; parallel to $I$, fibrous. Occurs also in laminated masses, often of large size ; in fibrous masses, with a satin lustre; in stellated or radiating forms consisting of narrow laminæ; also granular and com-
 pact.
When pure and crystallized it is as clear and pellucid as glass, and has a pearly lustre. Other varieties are gray, yellow, reddish, brownish, and even black, and opaque. H. = $15-2$, or so soft as to be scratched by the finger-nail. G. $=2 \cdot 33$. The plates bend in one direction and are brittle in another.

Composition. $\mathrm{CaO}_{4} \mathrm{~S}+2 \mathrm{aq}=$ Sulphur trioxide 46.5 , lime $32 \cdot 6$, water $20 \cdot 9=100$. B.B. becomes instantly white and opaque and exfoliates, and then fuses to a globule, which when placed upon moistened turmeric paper shows an alkaline reaction. In a closed tube much water is given off. Dissolves quietly in hydrochloric acid; and the solution gives a heavy precipitate with barium chloride.

The principal varieties are as follows:
Selenite, including the transparent crystallized gypsum, so called in allusion to its color and lustre from selene, the Greek word for moon.

Radiated and Plumose gypsum, having a radiated structure.

Fibrous gypsum or satin spar, white and delicately fibrous.
Snowy gypsum and Alabaster, including the white or lightcolored compact gypsum having a very fine grain.

Diff. The foliated gypsum resembles some varieties of heulandite, stilbite, talc, and mica; and the fibrous looks like fibrous carbonate of lime, asbestus and some of the fibrous zeolites; but gypsum in all its varieties is readily distinguished by its softness; its becoming an opaque white powder immedistely and without fusion before the blowpipe, and by not effervescing or gelatinizing with acids.

Obs. Gypsum forms extensive beds in certain limestones and clay beds, and also occurs in volcanic regions. New York, near Lockport, affords beautiful selenite and snowy
gypsum in limestone. At Camillus and Manlius, N. Y., and in Davidson County, Tenn., are other localities. Fine crystals of the form represented in figure 5 come from Poland and Canficld, Ohio, and large groups of crystals from St. Mary's in Maryland. Troy, N. Y., also affords crystals in clay. In Mammoth Cave, Kentucky, alabaster occurs in imitation of flowers, leaves, shrubbery, and vines. Alabaster is obtained at Castelino in Italy, 35 miles from Leghorn. Massive gypsum occurs abundantly in New York, from Syracuso westward to the western extremity of Genesce County, accompanying the rocks which afford the brine springs; also in New Brunswick, especially at Hillsboro', where part is excellent alabaster; in Hants, Colchester, and other districts in Nova Scotia; also in Ohio, Illinois, Virginia, Tennessec, Arkansas, and Nova Scotia; and in connection with the Triassic beds of the Rocky Mountain region; also abundant in Nevada and California. It is abundant also in Europe.

Gypsum, when calcined, loses its water, becomes white, is easily ground to a powder. This powder, when mixed with a little water, takes up water again and becomes hard and compact. This gypsum is plaster of Paris, and is used for taking casts, making models, and for giving a hard finish to walls. Alabaster is cut into vases and various ornaments, statues, ctc. It owes its beauty for this purpose to its snowy whiteness, translucency, and fine texture. Moreover, owing to its softness, it can be cut or carved with common cutting instruments. Gypsum is ground up and used for improving soils.

## Anhydrite.-Anhydrous Calcium Sulphate.

Trimetric. In rectangular and rhombic prisms, cleaving easily in three directions, and readily breaking into square blocks. $\quad 1 \wedge I=100^{\circ} 30^{\prime} ; 1 \check{ } \wedge 1 \check{\imath}=85^{\circ}$ and $95^{\circ}$. Occurs also fibrous and lamellar, often contorted; also coarse and fine granular, and compact.

Color white, or tinged with gray, red, or blue. Lustre more or less pearly. 'Iransparent to subtranslucent. $\mathrm{H} .=3-3 \cdot 5$. G. $=2 \cdot 9-3$.

Composition. $\mathrm{CaO} \mathrm{O}_{4} \mathrm{~S}=$ Sulphur trioxide $58 \cdot 8$, lime $41 \cdot 2=100$. It is an anhydrous calcium sulphate. B.B. and with acids,

its reactinns are like those of gypsum, execpt, that in the closed thbe it gives no water.

A sealy massive variety romaining a little silira has been named löprimte; contorted comeretionary hods are sometimes called Tripestome. Anhydrate is called hy miners hardplester, beranse harder than $\dot{6}$ ysum.

Joff. It sequare forms of crystallization and deavage are
 sugh angen with one amoner, low as if the eryallaztion were culher f but there is some diferemer in the case whth which they may be ohtanod.
 sum and calcareons spir in a hark limenome at. Lowhert, and near Whmoor in Nova Scota, and Hillohore m Now Braswick. Fornion locahties are at the salt moner of bux in Kwitzertant, Hall in the 'Tymol, I-chl in C Inere Austria,


The whome rarney ws sometimes rut and polished for ornamental prorones.

Jabilite. A hedrous calcium boralw occurrine as an incrustation at the 'Tascan laroons, Italy, A "hydrous torate of lime" reported by Hayes from Gquigut, Dern, has inend called Megesim ; hut sta composition has heren gurstioned, it being refered io Clexite. Momete. A hydrons calema borate, contaminer silia; Windsor, Ninat sotna.

 agereqratons of fibres, from the dry hams of lquque, Southern Pram: Nosa sotota, at IImbor, Brombilh, and Nowport; and Novada, in Columbus mining distriet, aded at 'lhel Salt Marnh, in Lenmeraha Countr.
('rintumurnite. Another hydroas calcinm-sodium horate; Windsor, Nova Sotha. friefte is a caldimm borate of whor color and chally aspert, from C'urry Conatr, Oregon.
 gypum in anowe

Sherlite. (allitum tometate, of pale yellowinh-white rolor: Il.







## Apatite- Calcium Phosphate.

Hexagomal. In hesagonal prinms. The annoxel figure repreents a common form. Chearamimpuftet. Isuatly ocurs an cryotals; but occasionally masthe; fometimes
mammillary with a compact fibrous structure. small ervitals are occasionally tramsparent and colorless, but the wanal color is preen, often yellowish green, blush green, and grayjwh green: sometimes yellow, hate, reddroh or bownish. Coarse cryats mearly opaque.
 $=3-3 \cdots 5$. Brittle. Some varietres phopho-
 peese when heated, and some become electrie hy firition.

 When ehlorthe is preselt in phace of flomene it is called


 the bones aml heaments of ammate, and the momeral has ponahly ben deracel in many cane from ammal fownls.*


 hary name from Crown Pomb, Eser Comaty, N. Y.
 rooks. and sometmes romstithte extended beds: and they comeist chafly of cakemp phophate. (intmo comtams more or Lese calcinm phosphate along with hyrons phophates and somm impuritur.

Jiff. Distmpurhed from heryl he its inferior hambes, it bëmg (andy seratrhed what a knife; from calcite by dis-

 before the bowpure Phophore acolmay be detexted by
 when it mparts a dirty areen color to the flame.
 schist, erambar limentome. In meroseopme eryatal it is gramoly preselt in amost all crystallme rocks, the iogmons as well as meramorphice. The hat erystals in the Unted states orewr in grambar lomestme : the ersotals from the limostone of St. Latwrence ('mmty. N. Y., are

[^2]among the largest yet discovered in any part of the world; one from Robinson's farm measured a foot in length and weighed 18 pounds; lout they are nearly opaque and the edges are usually rounded. They oceur with scapolite, sphene, etc. Edenville and Amity, Orange County, N. Y., afford fine crystals from half an inch to fwelre inches long. At Westmorchand, N. IL., fine crystals are obtamed in a rein of feldspar and guartz; also at Bhe Hill Bay in Maine. Bolton, Chesterfieh, Chester, Mass, are other localities. A beautiful hue raricty is obtained at Dixon's quarry, Wilmington, Delaware. Abundant in Burgese, Ehmsley, Grand Calumet Id., Hall, Buchingham, Portland, ete., in Camada.

The name apatite, from the Greck ("palao, to deceive, wis giren in allusion to the mistake of early mineralogists respecting the nature of some of its varieties.

A patite, when abmodant, is used like guano as a fertilizer, on aceount of its phophoric acd. 'lo mahe it capable of being taken up by phants it is treated first with a small portion of sulphuric acod, which renders the phosphorie acid soluble. When guano has been arcumblated by birts, or other anmals, orer enral rock, a calcium carbomate (as on somo coral ishands), the waters in filtrating through it have often carried down the woluble phosphorie acid or phosphates into the underlying beds and turned them into calcium phosphate.

Brushite and Mitarrushite. Mydrous calcium phosphates, found in guano.

Pyrophospharite. A white earthy phocphate from a gaano depnsit, in the West Indies. Analysis gave it the composition of a prrophosphate.
Pharmarolite and Huidingrerite are hrdrous calcium arsenates.
Nitrocnlcit: Hydrous calcium nitrate. From caverns.
Pyrochlure. Occurs in small brows and brownish-yellow ismmetric octahedrons. A calcium-cerium colunbatr. $\quad$ a. $=43-4$ 5. From Norway, Siberia.

Microlite. In crystals similar in form th those of pyrochlore, but in composition a calcium tantalate. G. =5:5-6. From Chesterfield, Mass., and Redding, Conn. Hotchuttolite is a lime-uranium columbate, from North Carolima.
Hisanalyte. In cubes in granular limestone, a columbate aud titanate of calcium, cerium and iron. From the Kaiserstuhl.

Romeite and Atopite are calcium antimonates, the latter containing also iron and soda.

## Calcite-Calc Spar. Calcium Carbonate.

Rhombohedral. $R \wedge R($ fig. 1$)=105^{\circ} 5^{\prime}$. Cleavage casy, parallel with the faces of the fundamental rhombohedron.


Calcite with the form in fire $r$ is often ealled dog-tooth sper. Ocours blans with a shlhy lustre : sometomes lamellar: offon coarou time ranular. and compact.

The pures orytals are transparent with a vitreous lustre ; the impure massive varieties are often opaque, and without lustre, and wen carthy. The colors of the erystals are cither white or some light grayish, reddeh or yellowhoh tint, rarely deep red ; oceasionally toma-yellow, pose or volet. The massive varieties are of varmas shades from white to black, genorally dull unless pohshed. II $=3$. $(i=2 \cdot 2 \cdot 2.8$

Compusilion. (:a $\mathrm{O}_{3} \mathrm{C}=$ Carbon dioxide 44 , lime $50=100$. Sometimes impure from mixture whth irom, slica, clay, bitmmen, and other subtances. lib. infushle: colors the flame redheh. gives up its carbon hovide, is therehy made canstie, in which state it wives an alhaline reaction. Effervesere in dilute cold hydrochbore acid. Many varneties phowhoresee when heateid.

The following are the promejpal varietios.
Ieclent spar. Tramsarent rastallme calcite, first brought from Iceland. Shows well double refraction.

Salin spar. A finely fibrous varioly with a satim lustre. Receives a handame polish. Occurs usually in veins traversing rocks of diferent kinds.

Chalh. White and earthy, without lustre, and so soft as
to leave a trace on a board. Forms mountain beds. Most chalk was made chiefly out of the shells of Mhizopods.

Rock molli. White and carthy like chalk, but still softer, and very fragile. It is deposited from waters containing lime in solution. Rock meal is a powdery variety.
chereront: fufa. Formed by deposition from waters like rock milh, but more cellular or porous and not so soft.

Stalertite, stalagmate. The name stalactite ivexplained on pase (i). The depesits of the same orgen that corer the floors of caverns are called stalagmite. They generally cousist of differently colored layers, and appear banded or striped when broken. 'The so-called " (iibraltar rock" is stalasmite from a carern in the rock of dibraltar.

Limestone is a reneral name for all the massive varieties occurring in estensive beds.

Oülite" P'solute. Oölite is a compact limestome, consisting of small romol comoretonary grans, looknir lake the spatwn of a fish; the name se derived from the Gerek änn. an eqt. Prenhte, a name derived from masm, the Latin for pea, differs from oolite in being comror : the spherules often hate a concentrestructure, and thus show their concretionary orimin.

Argertine. A white shining limestone consisting of lamone a hithe warmg, and eontammor some silica.
fontuincblecul limestone. Thas name is apphom to crystale of the form shown in figure 3 , contaning a large proporturn of sand, and oceurmor in grous. They were formerly obtaned at Fontandbean, France, but the locality 1s exhameted.
(iratuletr limestone. A limestone consibiner of reystalline grains, and hence often called erystellime limestone. The couser varietes when polished constatute the common arhite and rloudeld morbles, and are the material of whinh "marble" buldings are made. The fince are uned for statuary, and are called stotutury marble. The hest is as clear and fincerraned as loaf sugar, whoch it much resrmbles.

Compart lamestone. The limestones breakmg with a smooth surface, whont a distmonly eramular texture, and dull in lustre unless polished. The rock is very variously colored. The colors are sometimes arranged in blotches, or veins. Kinds that are handsome when polished are used as marbles. A black color is common, and is usually due to
rarbonaceons material of organic origin, and is proved by the limestones beeoming white when burnt.

Stinkstone, Anthracomite. A limestone which gives oub a fetid odor when struck. This odor is caused ly certain bituminous materials present in the rock.

Lithograpluc stone. A very compact finc-orrained limestone of a gray or grayish-yellow color.

Hydradir limestone. An impure limestone. It contains siliea and alumina in such a condition that, when burned, it will make a cement that hardens under water.

Diff. Distinguished by being seratehed easly with a knife, in comnertion with strongly efherveciner in dilute adid, and its complete infusibilaty. Caleite is not so hard as arasonite, and posesses a very distinct cleatage, which araromite does not.
(obs. Crystallized calo spar oceurs in magnifieent forms in the ricinity of Rossie, New York. Ond arystal from there now in the Peabody Museum at New Haven, weighs $16 i$ pounds. Some rose and purple vandens from this resion are sery beatiful. hare geodes of the dom-tooth epar rariety ocrur in homosone at lowkert, along with gypum and prat epar. Leyden and Lowville. N. Y., are other locahties. Bergen Mill, N. J., affords beautiful whe-rollow crestals in ampedalodal ravitios: ato the Laho Superion ropper mones. Aryentine oceurs near Wilhamsbure and sonthampton, Mare. Row mill covers the sudes of a cave at Watertown, N. Y., and is now formmer stalnefites of great bauty oceur in 1 eires and other caves 10 Virginia abl in the Western States: atoom Ball's Gave at Sooharie, N. Y. Chuth oeeurs in Encrand and Europe, and on Western Kansas in the L'med Nitates. Granalar limestones are eommon in the Fastern and Allantie sitates. and eompart limestones in the Midde and Western states, and some beds of the former afford werellent marble for buiding and some of good quality for statwary.

Any of the rarieties of this mineral when burnt form quicklime. heat drwing off the carbonic acid and leaving the lime m a canstie state. In this state it is used for making mortar by mixing with water and sand; a calciom hydrate results which beromes slowly earbonated through carbonic acid in the atmosphere. See further the chapter on liochs, for the uses of limestone.

## Aragonite.

Trimetric. In rhombic prisms; $I \wedge I=110^{\circ} 10^{\prime}$. Cleavage parallel with $I$. Usually in compound erystals having the form of a hexagonal prism, with uneven or striated sides; or in stcllated forms consisting of two or three flat crystals erossing one another. Transverse sections of some of the compound crystals are shown in figs. 1 to 4.


Occurs also in globular and coralloidal shapes; aiso in fibrons seams in different rocks.

Color white or with hght tinges of gray, yellow, green and riolet. Lustre vitreons. 'Iransparent to translucent. II = $32-4 . \quad(x=2.031$.

Composition. Same as for calcite, and its action before the blowpipe and with acids is the same, except, that it falls to powder readily when heated. Some varieties contain a fow per cent. of strontium carbonate, but this is not an essential ineredient. Distinguished from calcite by the absence of the cleavage of the latter, as woll as the crystalline form ; also by its higher specifie gravity.

Obe. Aragonite occurs mostly in grpsim hords and in ormoection with iron ores; also in basalt amd other rocko. The comalloidal forms are found on iron ore beds, and are called f'los ferri, flowers of iron. They look like a loosely intertwined or tangled white cord.

The fos-ferri variety occurs at Lookport with gypsum ; also at Edenville, at the Parish iron ore hed in Rosicie, and in Chester County, Pennsylvania. Aragon in Spain affords six-siled prisms of aragonite, associated with gypsum. 'This locality rave the name to the rpecies. Also found at Bilin, in Bolicimia, Tamowitz in Silesia, and other phaces.

## Dolomite.-Calcium-Magnesium Carbonate. Magnesian Carbonate of Lime.

Rhombohertral. $\quad R \wedge R=105^{\circ} 15^{\prime}$. Cleavage perfect parallel to $l i$. Faces of rhombohedrons sometimes curved, as in the amexed figure. Often granular and massive, constituting extensive beds.

Color white or tinged with yellow, red, green, brown, and sometimes hack. Lustre vitreous or poarly. Nearly transparent to translucent. Brit-
 tle. $11 .=3 \cdot 5-4 . \quad(\mathrm{x} .=2 \cdot 8-9 \cdot 9$.

Compoxition. $\frac{1}{2}\left(\mathrm{ar} \mathrm{Mg} \mathrm{O}_{3} \mathrm{C}=\right.$ Calcium carbonate 54.35 , magnesium (arbonate $45 \cdot(6=100$. Some non or manganese is often present, replacing part of tho magnesium or calcium. Dolomite resembles calcito, lut differs in that unless fincly pulverized it, cfferseses very sparingly, if at all, in cold dilute hydrochtoric acid.

The proncpal varieties of this species are as follows:
Iolomite. White, crystallme gramular, offen not distinguishahke in external characters from grannar limestone.

Pearl spar. In pearly rhombohedrons with curved faces.
iflomb spat, Droan spat. In thombohedrons, which become brown on exposure, owing to their contaning 5 to 10 per eent. of oxide of iron or manganese.

A cohalthferous variety has a red tint. A white compact riliecons variety has been called diurhofite. Some hyarauhe limestones are dolomite.

Diff. Distinctive characters noarly the same as for calrite. It is harder than that speress and duffers in the angles of its erystals and efferresees much less freely; but chemieal analysis so often required to distingush them.
(ox. Massive dolomite is commom in Western New England and Southeastern New York, and constitutes much of the marble used for building. (rystallized specimens are ohtained at the Quarmatine, Richmond Comety, N. Y. Rhombs spar oceurs in take, at smithfich. R. I.: Marlboro', Vt.; Middlefield. Mass. ; pearl spar in crystals of the above form at lockport, Niagara Falls, Rochester, Cilen's Falls: gurbofite on Hustis's farm, Phillipstown, N. Y.

Dolomite was named in honor of tho geologist and fravoler, Dolomien.

Solomite burns to quicklime like calcite, and affords a more durable cement. The white massive rariety is used
extensively as marble. The magnesian lime has been supposed to injure soils; but this is believed not to be the case if it is air-slaked before being used. It is also employed in the manufacture of Epsom salta or magnesium sulphate.

Ankeritc. Resembles brown spar, and, like that, beeomes brown on exposure Fundamental from a rhombohedron of 101 12. It is a calcium-magnesium-rron-and-manganese carbonate. 'The Styrian iron ore beds of saltaburg are some of its forengn localities; It occurs in Nura Scotia, and in quartz veins on Western New Hampshire ; Quebec, Canada, ete
Hydrodulomite. A calcium-magnesium carbonate containing water. Pennite from Texas, Pa., is similar.

## BARIUM and Stronticm.

Barinm and strontium occur in mature only in anhydrous ternary compounts of the following kinds: sulphate, carbomate, silicate ; and in silicates only in eombination with other basid elements. The species are chatarterized hy hierh specific eratitr, fanging from : $: 3$ to $4 \%$ Strontium gites ared color to the blowper flame : and harium, if strontium and other base dements are absent, a charactoristio green color.

Barite-Hrary Spar. Barium Sulphate.
Trimetric. In momitied thombu and rectangular prisms.
 tals mandly tabmar. Marsive barictios often coarse lamellar ;
 also colummar, fhrons. gramm5. lar and compact. Lastre vitreous; sometimes pearly. Color white and sometimes tinged yollow, red, brown, bhac. or dark brown. Tramsparent or
 $=4 \cdot 3-4 \cdot \%$

Composition. $\quad \mathrm{Ba}_{1} \mathrm{O}_{1} \mathrm{~S}=$ Sulphur triovile $34 \%$, haryta $65=100$. Strontium and calcium are sometmes present rophacing a lathe harmm. B. B. fueses to a head which racts alhaline. Imparts a green color to the flame. Alter fusion
with sola in the reducing flame on coal, and then phacod on a silver coin and moistened, it produces a black stan, due to sulphur.

Barite is often present in mineral veins as the gangue of the ore. In this way it occurs at Cheshire, Comm. Hatfield, Mass.; Rossic and Hammond, New York; lerkiomen, Pemsylvania, and the lead mines of the Miswissiphi Valley. Scoharie, and Pillar Point near Sacketts Harbor, are of her localities; ahso near Frederichsharg and elsewhere, Virginia; Nova Keotia, ete. The variety from Pollar Point receites a fine polish and looks like marble, the colors being in bands or clouds.

Heary par is gromd up and usch to admlterate whate lead. When white lead is mixed in erpal parts with it, it is sometimes called Vemice uhite, and amother quality with twiee its weight of barite is called Hamburg white, and another, onothind white lead, salled Inutif whito. When the material is very white, a proportion of it gives greater opacity to the rolor, and protects the lead from beine speedhy hackemed by suphurous vapors: and the en maxtures are therefore pefered for certain hinds of paintme.
Dreclitic is a barium-calcium sulphate.

## Witherite--Barium Carbonate.

Trimetric. $\quad I, I=118^{\circ} 30^{\prime}$. (leavage imperfect. Aloo in erohnalar or botryodal forms : often masole and either fibrous or granular. The massive varide des han matally a yellowish or grayish-white color, with a lustre a litele resinous, amd are tran-hecont. The cerstals are often white and nearly tramparent. Il.

(umposition. Ba $)_{3}(=$ ('arbon dioxime $2 \cdot 3$, baryta $\sigma \because=100$. B. B. deerpitanes and fuses easily, tingeing the flame green, to a translueent glohule, which becomes opayue on cooling, and colors a moistened turmerie paper red. Effervesces in hydrochlorice acid.


Diff. Wringruished by its specifie gravity and fusibility from calcite and aragonite; its
action with acids, from allied mincrals that are not carbonates; by yielding no metal, from cerussite, and by tingeing the flame green, from strontianite.

Obs. The most important foreign localities of witherite are at Fallowfield in Northumberland (where it is mined). Alstonmoor in Cumberland, and Anglezark in Lancashire. It is also found in Silesia, Styria, and Sicily. In the United States it occurs at Lexington, Ky.

Witherite, from Fallowfield, is used in chemical works, in the manufacture of plate glass, and in France in the manufacture of beet sugar.

Barytocalecte. Occurs at Alstonmoor in Cumberland, Fugland, in whitish monoclinic crystals. $H .=4$. $G=3 \cdot 6-3.7$. It is a barium. calcium carbonate.

Bromlite is a trimetric mineral, of the same composition, from Bromley Hill, ncar Alston, and from Northumberland, England.

Celestite-Strontium Sulphate.
Trimetric. $I \wedge I=103^{\circ} 30^{\prime}$ to $104^{\circ} 30^{\prime}$. Crystals rhombic prisms or tabular ; often long and slender. Cleavage distinct parallel with $I$. Mas-
 sive varicties : columnar or fibrous, forming layers half an inch or more thick with a pearly lustre ; rarely granvlar. Color gencrally a tinge of bluc, but sometimes clear white or reddish. Lustre vitreons or a little pearly; transparent to translucent. $\mathrm{H} .=3-3 \cdot 5 . \quad \mathrm{G} .=3 \cdot 9-4 . \quad$ Very britule.

Composition. $\mathrm{Sr}_{4} \mathrm{~S}=$ Sulphur trioxide $43 \cdot 6$, strontia $56.4=100$. B.B. decrepitates and fuses, tinging the flamo bright red to a milk-white alkaline globule, which gives an alkaline reaction. With soda on coal fuses to a mass which when moistened blackens silver.

Diff. From barite, which it resembles, it is distinguished by tho bright red color it imparts to the blowpipe fiame, and its less specific gravity; and from the carbonates, by not effervescing with acids.

Obs. Celestite is found in beds of sandstone or limestone, and also with gypsum, rock salt, and clay. A bluish celestine, in tabular and prismatic crystals, occurs at Strontian Island, Lake Erie; Scoharie, Lockport and Rossic, N.
Y., are other localities. A handsome fibrous variety occurs at Franktown, Huntingdon County, Ieunsylvania. Sicily affords fine crystallizations associated with sulphur.

The pale sky-blue tint, so common with the mineral, gave origin to the name celestite.

Celestite is used in the arts for making the nitrate of strontia, which is employed for producing a red color in fireworks.

## Strontianite.-Strontium Carbonate.

Trimetric. $I \wedge I=117^{\circ} 19^{\prime}$. Cleavage parallel to $I$, nearly perfect. Oceurs also fibrous and granular, and sometimes in globular shapes with a radiated structure within.

Color often a light tinge of green; also white, gray, and yellowish brown. Lustre vitreous, or somewhat resinous. Transparent to translucent. II. $=3 \cdot 5-4 . \quad \mathrm{G} .=3 \cdot 6-3 \cdot \% \mathrm{\sim}$. Brittle.

Composition. $\mathrm{Sr} \mathrm{O}_{8} \mathrm{C}=$ Carbon dioxide $29 \cdot \%$, strontia $70 \cdot 3=100$. A small part of the strontium is often replaced by calcium. B.B. swells, throws out little sprouts, but does not fuse. Colors the flame bright red, and after heating jossesses an alkaline reaction. Effervesces in cold dilute acid; sulphuric acid gives a precipitate of strontinm sulphate.

Diff. Its effervescence with acids distinguishes it from minerals that are not carbonates; the color of the flame before the blowpipe, from witherite and all other carbonates; calcium salts also give a red color to the flame, but the shade is yellowish, and less brilliant.

Obs. Strontianite occurs in limestone at Scoharic, N. Y., in crystals, and also fibrous and massive; and in Jeffersor: County, N. Y., and Mifflin County, Penn. Strontian in Argyleshire, England, was the first locality known, and gave the name to the mincral and the metal strontium. It occurs there, with galenite, in stellated and fibrous groups and in crystals.

This mineral is used for preparing the strontium nitrate.

## POTASSIUM and SODIUM.

Potassium and sodium occur in nature in the state of chloride, sulphate, nitrate, and carbonate, and are constituents in many sllicates.

## Sylvite.-Potassium Chloridc.

Isometric. White or colorless, with vitreous lustre, and taste nearly that of common salt. The crystals are often cubes with octahedral planes, like fig. 8 on P .19 . II. $=2$. $\mathrm{G} .=1 \cdot 9-2$.

Composition. $\mathrm{K} \mathrm{Cl}=$ Chlorine $47 \cdot 5$, potassium $52 \cdot 5=100$. From Vesuvius, about the fumaroles of the volcano.

Halite-Common Salt. Sodium Chloride.
Isometric. In cubes and other related forms. Sometimes crystals have the shape of a shallow four-sided cup, and are called hopper-shaped crystals; they were formed floating, the cup receiving its enlargement at the margin, this being the part which lay at the surface of the lirine where evaporation was going on. Cleavage enbic, perfect.

Color usually white or grayish. sometimes rose-red, yellow, and of ancthystine tints. 'laste saline. II. =2. G. = $2 \times 5 \%$ 。

Composition. $\mathrm{NaCl}=$ Chlorine $60 \%$, sodium $393=100$. Crackles or decrepitates when heated; fuses easily, coloring the flame deep yellow.

Diff. Distinguished by its taste, solubility, and blowpipe characters.

Obs. Salt oceurs in extensive hut irregular beds, usually associated with gypsum, anhydrite, and clays or sandstone. It uccurs in formations of all ages from the Silurian to the present time. It exists in the lyrenees, in the valley of Cardona and elsewhere, forming hills 300 in 400 feet high;
 range through Reichenthal in Bavaria, Hallein in
Hallstadt, Ischl and Ebensee in 5-bier Austria. in Styria; in IIungary at Marmoros and elsewhere; if Transylvania, Wallachia, Galicia and Upper Silesa; at Vic and Dieuze in France; at Bex in Switzerland; in Cheshire, England; in Northern Africa in vast quantities forming hills and extended plains; in Northern Persia at Tiflis, in India in the province of Lahore, and in the valley of Cashmere ; in China and Asiatic Russia; in South America, in Pern and the Cordilleras of New Gramada.

Among the most remarkable deposits are those of Poland and Hungary. The former, near Cracow, have been worked since the year 1251, and it is calculated that there is still
enough salt remaining to supply the whole world for many centuries. Its deep subterranean regions are excavated into houses, chapels and other ornamental forms, the roof being supported by pillars of salt ; and when illuminated by lamps and torches, they are objects of great splendor.

The salt is often impure with clay, and is purified by dissolving it in large chambers, drawing it off after it has settled, and craporating it again. The salt of Norwich (in Cheshire) is in masses 5 to 8 foet in diameter, which are neanly pure, and it is prepared for use by erushing it between rollers.

In North America, beds of rock sall exist at Gooderich in Canada: at Wyoming in Western New York (reached by boring to a depth of 1,289 fent) ; in Wrashington Comnty, in Virginia ; and extensively at letite Anse in Louisiana, where it underthes 144 aeres; in Nevada, at several localities; in the Sahmon River Mountains, Oregon.

Brine springe also proceed from rocks of varions ages; and often they are indications of deep-seated beds of rock falt.

The salt of Western New Sork, and Goderich, Canada, is of the Sahma perios of the Upper Silurian ; the brine springe of Michigan. from shates and marlytes of the Sulbcambniferous period; those of the salt heds of Norwich, England, in magnexim limestone of the Permian; those of the Vosess and of Saltzhare, behl, and the neighboring regions, in marly sandstone of the 'lriassic ; those of Bex, in Swatzerland, in the Lias formation; that of Wieliraka, Poland, and the Pyrenees, in the Cretaceons or chalk formation; that of Catalonia, in the Tertiary ; that of Lominiana, 14 the Quatemary, and harge deposits are still more rerent; and bosides there are lakes that are now evaporating and producing salt depositions.

Vast Jakes of salt water exist in many parts of the world. The (ireat salt Lake of Whah has an area of o.000 square miles, and is remarkable for its extent, considering that it is situated toward the summit of the Rocky Mountains, at an elevaton of 4,200 feet above the sea. lis waters contain $2^{0}$ per eont. of sohlum (hlorile (common sali). The dry regions of these mountans and of Southwertern California are noted for salt licks and lakes. In Northern Africa larere lakes as well as hills of sald, abomm, and the deserts of this region and Arabia abound in saline deflorescences.

The Dead and Caspian Seas, and the lakes of Khoordistan, are salt. From $20-20$ per cent. of the weight of the water from the Dead Sea are solid salts, of which 10 per cont. are common salt. Over the pampas of La I'lata and Patagonia there are many ponds and lakes of salt water.

The greater part of the salt made in this comentry is obtained by evaporation from salt springs. Those of salina and Symacuse are well known ; and many nomly as valuable are worked in Ohio and other Westem States. At the best New Tork springs a bushel of salt is obtained from every 40 gallons. But the discovery of rock salt at Wyoming, west of Sracuse, may lead to further diseoveries, which will make the brines of New York of comparatively little value. 'To obtain the brine, wells from a0 to 150 feet deep are sunk by boring. It is then raised by machinery.

The process of eraporation under the heat of the sum is extensively employed in hot climates for making salt from sea water, which affords a bushel for every 300 or 350 gatlons. For this purpose a momber of large shallow basins are made adjoining the sea; they have a smooth botom of clay, and all eommunicate with one amother. The water is let in at high tude and then rhut off for the evaporation to go on. This is the simplest mode, and is used even in uncivilized countries, as among the Pacific Islands.

## Mirabilite.-Glauber Salt. Uydrous Sodium Sulphate.

Monoclinic. Oceurs in efflorescent crusts of a white or yellowish-white color ; also in many mineral waters. Taste cool, then fecbly salme and bitter.

Composition. $\mathrm{Nit}_{2} \mathrm{O}_{4} \mathrm{~S}+10 \mathrm{ar}=$ Snlphur trioxide 24.8 , soda $19 \cdot 3$, water $509=100$.

Ifff. It is distinguished from Epsom salt, for whinh it is sometimes mistaken, by its coarse erystals, and the yollow color it gives to the howpipe flame.

It is mate in chormous amounts from common salt, its production being one stage in the manufacture of sodium carbonate. It is used in medicine, and is known by the familiar name of "salts."
()bs. On Hawaij, one of the Sandwich Islands, in a cave at Kailua, Glauber sait is abundant, and is constantly forming. It is obtained by the natives and used as medicine. Glaber salt oecurs in efforescences on the limestone balow

Genesee Falls, near Rochester, N.Y. It is also obtained in Austria, Hungary, and elsewhere in Europe.

The artificial salt was first discovered by a German chemist by the name of Glauber.

Aphthitclite (Arcanite). Potessinm sulphate, $\mathrm{K}_{2} \mathrm{O}_{4} \mathrm{~S}=$ Sulphate tri oxide 45.9, potash $54 \cdot 1=100$. Found at Vesuvius. Misenite is a bydrous potassium sulphate from a cavern near Misene.

Thenardite. Sordium sulphate $\mathrm{Na}_{2} \mathrm{O}_{4} \mathrm{~S}=$ Sulphur trioxide 437 , soda $563=100$. From Spain, Bolivia, Tarapaca, in Pera; Slate Range, San Bernardino (\%., C'alifornia; and in Nevada.

Glauberite. Sodium-calcium sulphate. In monoclinic crystals, at Villa Rubia, in New Castile, Aussee, in Austria, and other salt beds.

Polyhalitc and l'ifromerite are hydrous magnesium-potassium sulphates; Bledite and Lore ite hydrous magnesium-sodium sulphates; syngonitc, a hydrous calcium-potassium sulphate.

Borax.-Hydrous Sodium Biborate. Tinkal.
Monoclinic. In oblique rhombie prisms $I \wedge I=8^{* \prime}$. ('learare parallel with $i-i$ perfect. The erystals are white and
 Taste swoetioh-alhahne.
(ompusilion. $\mathrm{Nit}_{2} \mathrm{O}_{2} \mathrm{~B}_{4}+10 \mathrm{aq}=$ Boron trioxide $30 \cdot \mathrm{fi}$, sola $16 \%$ water $4 \%=100$. B. $\%$. swells up to many times its bulk and becomes opaque white, and finally fuses to a glassy clohule.

Obs. Dorax was originally hronght from a salt lake in Thbet, whore it is dur in consaderable mases from the edges and shallow parts of the lakes. The holes thus made in a short tume become filled again with horax. The crude boras was formerly sent to Europe under the name of tinFobl. and there purfied for the arts. It has ako been found in Pern and Ceylon. It has been extensively made from the boracic acid of the Tuscan latroons by the reaction of this acid on sodum carbonate.

Borax oceurs under like circomstances in Cahifomia and Nevala, or is manufactured from other borates in solution or in the solid state. Lacalitios in California are Boran Lake and its vicinity, north of Sin Franciseo; also near Walker's Pass, Sierra Novada; at Mono and Owens Lakes, and at Death Valley, near the borders of Nevada; in the Slate Range, in Sim Bernardino (oomty; and in Nevada, at Lattle Salt Lake, near Ragtown, on the Pacifie Railroad, and at Cohumbus Miarh. The Columbus Marsh, in Nevada, near lat. $35^{\circ} 5^{\prime} \mathrm{N}$. and long. $118^{\circ} \mathrm{W} ., 46$ miles
north of trail from Mono Lake, is a deposit, 10 miles long by 7 wide, of borates and other salts, chedly borax, calcium borate, sodium sulphate, and common salt. The large deposits of "priceite" in Southern Oregon, and of ulexite, in the "Cane Spring District," "0 miles west of Sin Bernardino, and at the Columbus Marsh, are other sources of borax. The amount of borax received at San Francisco during the year $1 s^{6} 6$ was $5,180,910$ pounds, and in $18 \% \%$, $4.154, \% 09$ pounds.

## Nitre.-Potassium Nitrate.

Trimetric. In motified right rhonbic prisms. $I: I=$ $118^{\circ} 50^{\prime}$. Usually in thin white subtramsparent crusts, and me nedeform crystals on old walls and in caverns. T'aste saline and cooling. $\quad H=0 . \quad\left(\dot{x}=1 \cdot 9^{*}\right.$.

Composition. $\mathrm{K}_{2} \mathrm{O}_{3} \mathrm{~N}=$ Nitrogen pentoxide $\left(\mathrm{N}_{2} \mathrm{O}_{5}\right) 53 \cdot 4$, potash 46 (i. Burns vaidy on a live coal.

Itiff. Distinguished readily by its taste and its virid action on a live coal : and from sorlium nitrate, which it most resembles, by its not becoming liquid on exposure to the air.

Nitre, called also saltpetre, is employed in making gunpowder, formmig to to is per eent, in shooting powder, and 6: in minner powler. The other materials are sulphar ( 10 per cent., for shootmg powder to 20 for mimmes) and charcoal (12 to 14 for shootimer powder and is for mining). It is ako extensively usid in the manufacture of notro and sulphuric acids ; also for protechme purposes, fulminating powders, and saringly in medocine.

Obs. Occurs in many of the caverns of Kentucky and other Western states, scattered throngh the carth that forms the floor of the case. In procuring it, the earth is hivivated, and the lye, when evaporated, yields the nitre. India is its most abondant locality, where it is obtained largely for exportation.

Spain and Erypt also afford laree quantities of nitre for commeree. This salt forms on the ground in the hot weather succeedmy eopions rains, and appars in silky tufts or eflorescences : these are brashed up hy a kind of hroom, lixiviated, and atter setthor, evaporated and orystallazed. In France, (iemmay, Sweden, Hungary, and other countries, there are artifictal arrangements called nitriotics or nitre beds, from which mate is obtained by the decomposition
mostly of the nitrates of lime and magnesia which form in these beds. Rofuse animal and vegetable matter putrefied in contact with caleareons soils produces nitrate of lime, which affords the mitre by reaction with carbonate of potash. Old plaster lixiviated affords about 5 per cent. This last method is much used in France. The nitric acid of the cavern nitrates comes from the atmosphere, which also consists of nitrogen and oxygen ; but the combination takes pace through the ageney of a peculiar kind of microscopic plant.

## Nitratine.-Soda Nitre. Sodium Nitrate Cubic Nitre.

Rhombohedral ; $R: R=106^{\circ} 33^{\prime}$. Also in crusts or efflorescences, of white, grayish and brownish colors. Taste cooling. Soluble and very deliquescent.

Composition. $\mathrm{Na}_{2} \mathrm{O}_{3} \mathrm{~N}=\mathrm{N}$ trogen jentoxide 6.3 .5 , soda $36 \cdot 5=100$. Burns vividly on coal, with a yollow light.

Diff. It resembles nitre (saltpetre), bat deliquesces, and gives a deep yellow hoht when burning.

Obs. In the dietriet of 'Taramaca, Northern Chili, the dry Pampa for an extent of forty leagues is covered with beds of this salt, mixed with gipsum, common salt, glauber salt, and remains of recent shells.

It is used extensively in the manufacture of nitric acid. It is also used in making nitre by replacing the sotime by putassimm. In 186if, one million quintals of this salt were exported from Chili.

## Natron.-- Hydrous Sodium Carbonate. Carbonate of Soda.

Monoclinic. Gencrally in white effloreseent crusts, sometimes yellowish or grayish. Jaste alkahne. Ettoresces on exposure, and the surfice becomes white and pulverulent.

Composition. $\mathrm{Na}_{2} \mathrm{O}_{3}(;+10 \mathrm{aq}=\mathrm{Carbon}$ dioxide $26 \cdot \hat{6}$, soda 18.8, water $54 \%=10 \%$. Effermees strongly with acids.

Diff. Distinguished from other soda salts by effervescing, and from trona, by efllorescing on exposure.

Oles. This salt is found in solution in certain waters, from which it is erystallized in efllorescences by evaporation. Ahundant in the soda lakes of Erypt ; also in lakes at Debreezin, in Hungary ; in Mexico, north of Zacatecas, and elsewhere. Sparingly dissolved in the Seltzer and Carlsbad waters.

This salt (but the artificially prepared) is extensively used in the manufacture of soap and glass, and for many other purposes.

Trona. A hydrous sodium sesquicarbonate occurs in the province of Suckenna, in Africa, between Tripoli and Fezzan, where it forms a fibrous layer an inch thick beneath the soil. It is abundant at a lake in Maracaibo, 48 miles from Menduza; and forms an extensive bed in Churchill County, Nevada.

Thermonatrite. A hydrous sodium carbonate of the formula $\mathrm{Na}_{2}$ $\mathrm{O}_{3} \mathrm{C}+\mathrm{aq}$. An anhydrous sodium carbonate is stated to exist native.

Gay-Lussite. Occurs in white brittle monoclinic crystals. Composition $\pm \mathrm{Na}_{2} \mathrm{CaO}_{3} \mathrm{C}^{\mathrm{C}}+2+\mathrm{aq}$. From Lagunilla, in Maracaibo, and Little Salt Lake, near Ragtown, in Nevada.

## AMMONIUM.

The salts of ammonia are more or less soluble in water, and are entirely and easily volatilized before the blowpipe. When treated with caustio lime or potassa. anmonia is liberated, and is recognized by its odor and the reaction of the vapors on test papers.

> Salmiak.-Sal Ammoniac, Ammonium Chloride.

Ocours in white crusts or efforescences, often vellowish or gray, Crystallizes in regular octahedrons. Transluecent -opaque. 'laste sahme and pungent. Soluble in three parts of water.
 100. dives off the odor of ammonuce when powdered and mixed with quicklime.

O/s. Occurs in many roleanie regions, as at Etna, Vesuvins, and the samblach lslands, where it is a product of volcanic action. Occasionally found about ignited coal seams.

The sal ammoniac of commerce is manufactured from anmal matter or coal soot. It is generally formed in chimneys of both wood and coal fires. In kgypt, whence the greater part of this salt was formerly obtained, the fires of the peasantry are made of the dung of camels; and the soot which contains a considerable portion of the ammomiacal salt is preserved and carried in bags to the works, where it is obtained by sublimation. Bones and other animal matters are used in France. A liquid condensed in the gas works, is also used in its production.

It is a valuable article in medieine, and is employed ly timmen in soldering to prevent the oxidation of copper surfaces ; also in a varicty of metallurgical operations.

Mascagnite. A hydrous ammonium sulphate. In mealy crusts, of a yellowish-gray or lemon-yellow color; tranclucent ; taste pungent and lister. Composition $\left(\mathrm{N} \mathrm{H}_{4}\right)$ : $\mathrm{O}_{4} \mathrm{~S}+\mathrm{H}_{2} \mathrm{O}=$ Sulphur trinside $53 \cdot 3$, ammonia $22 \cdot 8$, water 239 . Easily soluble 10 water. Occurs at Etna, Vesuvius, and the Lipari lslands. It is one of the products from the combustion of anthracite coal.

Lecontite is hydrous ammonium-sodium sulphate. Bonssingaultite is a hydrous ammonium-magnesium sulphate, from Tuscany.

Atruritc. A hydrous ammonum-magnesium phosphate; occurring in yellowish crystals, slightly soluble in water; found on the site of an old church in Hamburg, where there had been quantities of catthe dung.

Twehcrmigite An ammonia alum from Tschermig, Bohemia, and Utah County, Utah

Larderellite. A white tasteless ammonium borate, from the Tuscan lagoons.
IIydrous ammamium phosphute and Ammonium becarlomate (Teschemarlerite) have been detected in guano; also, Hydrous sodium-ammonimin phosphate, called stereoritc.

## IIVDROMEN

Mydrogen is the hasic constiturnt in hydrochloric acid, and in water.

Hydrochloric Acid.-Muriatic Acid.
A mas, consisting of Chlorine $9 \cdot \cdots(6$, hydrogen $2 \cdot a t=1(1)$ $=I I$ Cl. It has a pomgent odor, and is acrid to the skin.

It is raphlly disiolved liy water. If passed into a solution of nitrate of silver, it produces a white precipitate which soon blackens on expmore. It is siven out, whenever (ommon salt is acted on by sulphuric acid, and ocoasionally by roleanoes.

## WATER.

Water (hydrogen oxide) is the well-known liquid of streams and wells. The purest matual water is obtamed by melting snow, or recriving rain in a clean ghass vessel : but it is absolutely pure only when procured hy distillation. It consists of hydrogen l part hy weight, and oxpen s parts, or hydrogen $11 \cdot 11$, oxygen ss-s! $=100$. It becomes solid at $32^{\circ}$ Fahrenheit (or 0 Centigrade), and then crystallizes, and constitutes ice or snow. The erystals are of the hexagonal system. Flakes of suow consist of a congeries of
minute crystals, and stars, like the figures on page 4, may often be detected with a glass. Various other alhed forms are also assumed. The rays meet at an angle of $60^{\circ}$, and the branchlets pass off at the same angle with perfeet regularity. The density of water is greatest at $39^{\circ}{ }^{\circ}{ }^{\prime} \mathrm{F}$; below this it expands as it approaches $3 z^{3}$, owing to incipient crystallization, and in the state of ice it is only 0.920 . It beils at $212^{\circ} \mathrm{F}$. A culvic inch of pure water at $62^{\circ} \mathrm{F}$. and 30 inches of the barometer. weighs $2 \boldsymbol{2}-4.58$ grains, which equals $16 \cdot 386$ grams ; and a cubic foot of water weighs $6 \times 355$ pounds aroirdupois. A pint, United States standard measure, holds just 4,342 troy grains of water, which is little above a pound avoirdupois ( $r, 000$ grains troy).

Water, as it occurs on the earth, contains some atmospherie air, without which the best wonld be umplatable. This ar, with some free oxygen also present, is necessary to the dife of aquatic amimals. In most spring water there is a minute proportion of salts of calcium (sulphate, chloride or carbonate), often with a trace of common salt, carbonate of magnesium and some alumina, iron, silua, phosphoric acid, carbone acid, and certain vegetable acids. These impurities constitute usually from ${ }_{1}^{10}$ to 10 parts, in 10.000 parts by weight. The water of Long Pont, near Buston, contains ahout $\frac{1}{2}$ a part in 10,000 ; the Schuylkill of Philadelphatabout, 1 part in 10,000 ; the Oroton, used in New York eaty, 1 to $1 \frac{1}{2}$ parts in 10,000 . Nitric acid is usually found in rain water combined with ammonia; river waters are ordinarily the purest of natural waters, unless they have flowed through a densely populated region.

Sea water contains from 30 to 89 parts of solid substances in solution in 1,000 parts of water. The lareest amount in the Athatic, 360 parts, is found under the equator, away from the land or the vicinity of frenh-water streams; and the smallest in narrow straits, as Dover Strats, where there are only $3 * 5$ parts. In the Baltic and Black Sas, the profortion is only one-third that in the open ocean. Of the whole, one-half to two-thirds is common salt (sodimm chloride). The other ingredients are magnesium salts (chloride and sulphate), amounting to four-fifths of the remainder, with sulphate and carbonate of calcium, and traces of bromides, iodides, phosphates, borates and fluorides. The water of the British Channel affords water $964 \cdot 7$ parts in 1,000, sodium chloride $27 \cdot 1$, potassium chloride $0 \cdot 8$, magnesium
chloride $3 \cdot \gamma$, magnesium sulphate $2 \cdot 30$, calcinm sulphate $1 \cdot 4$, calcium carbonate 0.03 , with some magnesium bromide and probably traces of iodides, fluorides, phosphates and borates. The bitter taste of sea water is owing to the salts of magnesinm present.

The waters of the Dead Sea contain 200 to 260 parts of solid matter in 1,000 parts (or 20 to 26 per cent.), including r to 10 per cent. of common salt, the same proportion of magnosian salts, principally the chloride, $2 \frac{1}{2}$ to $3 \frac{1}{2}$ per cent. of caleium carbonate and sulphate, besides some bromides and alumina. The density of these waters is owing to this large proportion of saline ingredents. The brme springs of New York and other States south and west, are wellknown sources of salt (see under Common salt). Many of the springs afford bromme, and lare quantitios of it are manufactured for making photographic phates and for other phrjorses.

Mineral waters rary much in constitution. They nften contain iron in the state of bicarbonate, like those of Saratoga and Ballstown, and are then called chalybete waters, from the ancient name for iron or steel, chelybs, derived from the name of a country on the Baltic. Hydrogen sulphide is often hed in mineral waters and imparts to them its odor and taste; such are the so-called sulphur springs.

Minute traces of salts of zinc, arsenice lean, enpper, antimony and tin, have been found in some waters. Whatever is solahke in a region through which waters flow, will of course be taken up by them, and many ingredients are soluble in minute proporitions, which are usually described as insoluble.

## III. SILICA AND sILICATES.

## I. SILIC'A.

## Quartz.

Rhomhohedral. Occurs usually in six-sided prisms, more or less modified, terminated with six-sided pyrameds : $h \wedge h$ $=94^{\circ} 15^{\prime}$. No cleavage apparent, seldom even in traces; but sometimes obtained by heating the crystal and plunging it into cold water. Sometimes in coarse radiated forms;
also coarse and fine granular ; also compact, cither amorphous, or presenting stalactitic and mammillary shapes.

Crystals often as pellucid as glass, and colorless; sometimes topaz-yellow, amethystine, rose, smoky, or other tints. Also of all degrees of tramparency to opaque, and of varions shades of yellow, red, green, blue and brown colors to black. In some varieties the colors are in bands, stripes, or clouds. $\Pi .=\% \quad(\mathrm{i} .=2 \cdot \mathrm{~b}-\mathrm{i} \cdot \mathrm{S}$.
5.


Composition. $\quad \mathrm{Si} \mathrm{O}_{2}=$ Oxygen $53 \cdot 33$, silicon $46 \cdot 6 \sigma^{\prime}=100$. Opapue varieties often contain oxide of iron, clay, chlorite, or some other mineral disseminated through them. B.B. infasible. With soda, fuses with effervescence.

Diff. Quartz is exceedingly various in color and form, but may be distingushen, by (1) absence of true cleavage; (2) its harduess; (3) its infusibility before the blowpipe: (4) its insolubility with cither of the common acids; (5) its effervescence when heated 13.13. with soda; and (i) when crystallized, by the forms of its crystals, which are almost always six-sided prisms terminating in six-sided pramids.

The varieties of quartz owe ther peouliarities either to crystallization, mode of formation, or impurities, and they fall naturally into three sories.
I. The ritroous varieties, distinguished by their slawy fracture.
II. The chalcolonic varicties, having a subvitreous or a wasy lustre, and generally tramslucent.
III. The juspery ryptocrystalline varietics, having barely a chimmering lustre or none, and opaque.

## I. VITREOUS VARIETIES.

Rork Crystre7. Pure pellucid quartz.
This is the mineral to which the word crystel was first applied by the ancients; it is derived from the (ireek krustallos, meaning ice. The pure specimens are often cut and used in jewelry, under the name of " white stone."

It is often used for optical instruments and spectacle
glasses, and even in ancient times was made into cups and vases. Nero is said to have dashed to pieces two cups of this kind on hearing of the revolt that caused his ruin, one of which cost him a sum equal to $\$ 3,000$.

Amethyst. Purple or bluish-violet, and ofien of great beauty. The color is owing to a trace of manganese oxide. It was called amethyst on account of its supposed preservative powers against intoxication. When finely and uniformly colored, highly esteemed as a gem.

Rose Quartz. Pink or rose-colored. Soldom occurs in crystals, int generally in masses much fractured, and imperfectly tramsparent. The color fades on exposure to the light, and on this account it is little used as an ornamental stone, yet is sometimes cut into cups and rases.

Folse Topaz. Light yellow pellucid crystals. They are often ent and set for topaz. The absence of cleavage distinguishes it from true topaz. The name citrine, often applied to this variety, alludes to its yellow color.

Smoky Quartz. Crystals of a sinoky tint; the color is eometimes so dark as to be nearly black and opaque except in splinters. It is the cairngorm stone.

Milhy (uartz. Milk-white, nearly opaque, massive, and of common oecurrence. It has often a greasy lustre, and is then called greasy quartz.

Prase. Leek-green, massive ; resembling some shades of beryl in tint, but easily distinguished by the absence of clearare and its infusibility. Supposed to be colored by a trace of irom silicate.

Aventurine Quartz. Common quartz spangled throughout with seales of colden-yellow mica. It is usually trinslucent, and gray, hrown, or reddish brown in color.

Fervuginous: Quartz. Opaque, and either of yellow, brownish-yellow, or red color. The color is due to the presence of iron oxide as an impurity, the red to the anhydrous oxide, and the brownish yellow to the hydruas oxide.

## II. CHALCEDONIC VARIETIES.

Chalcedony. Translucent, massive, with a olistening and somewhat waxy lustre ; usually of a pale grayish, bluish, or light brownish shade. Often oceurs lining or filling cavities in amygdaloidal rocks, and sometimes in other kinds. These cavities aro nothing but little carerns, into which siliceous waters have filtrated at some period. The stalactites are
"icicles" of chalcedony, hung from the roof of the carity. Some of these chalcedony grottos are several feet in diameter. Large geodes of this kind occur in the Keokuk limestone in Illinois and Iowa.

Chrysoprase. Apple-green chalcedony. It is colored by nickel.

Carnclian. A bright red chalcedony, generally of a clear rich tint. It is cut and polished and nuch used in the more common jewelry. It is often cut for seals and beads.
siard. A deep brownish-red chalcedony, of a blood-red color by trimsmitted light.
Agute. A rariegated chalcedony. The colors are distributed in clouds, spots, or coneentric lines. These lines take straight, circular, or zigzag forms ; and when the last it is called fortificution aygate, so named from the resemblance to the angular ontlines of a fortification. These lines are the edges of layers of chatecdony, and these layers are the successive deposits during the process of its formation. Mucha stone or Mass agate is a brownish agate, consisting of chalcedony with dendritic or moss-like delineations. of an opaque yellowi.h-brown color. They arise from disseminated iron oxide. All the varieties of agate are beatiful stomes when polished, but are not much used in fine jewelry. The colors may be darkened by boiling the stone in oil, and then dropping it into sulphuric acid; a little oil is absorbed by some of the layers, whech becomes blackened or charred by the acia.

Onyr. A kind of agate having the colors arranged in flat horizontal layers; the colors are usually light clear brown and an oparque white. When the stone consists of sard and white chalcedony in alternate layers, it is called sordonyr. Onyx is the material used for cameos, and is well fitted for this kind of miniature sculpture. The figure is carred out of one layer and stands in relief on another. A noted ancient cameo is the Mantuan rase at brunswick. It was cut from a single stone, and has the form of a creampot, about 7 inches high and $2 \frac{1}{2}$ broad. On its outwide, which is of a brown color, there are white and yellow groups of raised figures, representing Ceres and Irmelomus in search of Proserpine.

C'at's Eye is greenish-gray translncent chalcedony, having a peculiar opalescence, or glaring internal reflections, hike the eye of a cat, when cut with a spheroidal surface.

The effect is owing to filaments of asbestus. It comes from Ceylon and Malabar, ready cut and polished, and is a gom of considerable value.
f'lint, Hornstome. Massive compact silica. of dark shades of smoky gray, brown, or even black, and fecbly translucent, it breaking with sharp cutting edges and a conchoidal surface. Flint occurs in nodules of chalk: not unfrequently the nodules are in part chalcedonic. Hornstone differs from flint in being more brittle ; it is often found in limestone.

Chert is an impure hornstone. Limestones containing hornstone or chert are often called cherty limestone.

P'asma. $\Lambda$ faintly translucent variet $y$ of chaledony approaching jasper, of a green color, sprinkled with yellow and whitish dots.

## III. JASPERT VARIFTIES.

Tasper. A dull red or yellow siliceous rock, containing some clay and yellow or red iron oxide, the red, the anhydrotse oxide, and the yellow, the hydrous oxide. Heat drives off the water from the yellow jasper and turns it red. It also ocerurs of wren and other shades. Ribatul jorper is a jasper consishag of broal stripes of areen, yellow, gray, red, or hrown. Egyptian jasper consists of these colors in irrequar eoncentric zones, and occurs in nohbles, which are often eut across and polished. Ruin jorsper is a sarioty with delineations like ruins, of some brownish or yellowish shade on a darker ground. Porcelain jasper is nothing but a baked day, and differs from jasper in being fusible before the hlowpipe. Red felsyte resembles red jaseer ; but this is also fusible, and consists largely of foldspar.

Jitiver admats of a high polish, and is a handsome stone for imlaid work, but is not much used as a gem.
liloodstone or Heliotrope. Deep green, shohtly transJucent, containing spots of red. which have some resemhlance to drops of blood. It contains a few per cent. of clay and iron oxide mechanically combined with the silica. The red epots are colored with iron. There is a bust of Christ in the royal collection at Paris, cut in this stonc. in which the red spots are so managed as to represent drops of blood.

Lydiuen Stone, Touchatone, Besernite. Velvet-hlack and opaque, and used, on account of its havdness and back color, for trying the purity of the precions metals; this is
done by comparing the color of the mark left on it with that of an alloy of known character. The effect of acids ujon the mark is also noted.

Besides the above there are other rarieties arising from structure.

Tabular Quartz. Consists of thin plates, cither parallel or crossing one another and leaving large open cells.
(irronulur Gluartz. A rock consisting of quartz grains compactly cemented. The colors are white, gray, flesh-red, yollowish or reddsh-brown. It is a hard sliceons samdstone. Ordinary sandstone often consists of nearly pure quartz.

Pseudomorphous Quartz. Quartz under the forms of calcite, barite, fluorite or other mineral. Shells, corals, ete., are sometimes found converted into quartz by the ordinary process of petrifaction.

Nilicificel. Wond. Petrified wood often consists of quartz, quartz having taken the place of the original wood. Some specimens are petrified with chalcedony or agate.

Penctrating substances. Quartz crystals are sometimes penetrated by other minerals. Rutile, asbestus, actinolite, topaz, tourmaline, chlorite and epidote, are some of these suhstances. The rutile often looks like needtes or fine hairs of a brown color pasing through in ceery direction. They are cut for jewelry, and in France pass by the name of Fiteches dramour (love's arrows). The erystals of Herkimer Gounty, N. Y., often contain a kind of black coal. Other crystals contain cavities filled with some fluid, as water, maphtha, or liquid carbonic acid, or with minate crystals.

Ohs. Quartz is an essential constituent of granite, gneise, mica sehnst, and many other common roeks, and the chicef or only constitucnt of many sandstones, and of the sands of most sea-shores. Fine quartz erystals oceur in Herkimer County, Now York, at Middlefield, Litile Falls, Salisbury and Newport, in the soil and in cavities in a sandstone. The beds of iron ore at Fowler and Hermon, st. Lawrence County, afford dodecahedral erystals. Diamond Island. Lake Ceorge, Pelham and Chesterfield, Mass., Paris and Perry, Me., Meadow Mt., Md., and Inot Springs, Arhansas, are other localities. Irose quartz is fomm at Albany and Paris, Me., Acworth, N. II., and Southbury, Comn.; smoky quartz at Goshen, Mass.; Iaris, Me; in North Caro-
lina; at Pike's Peak, Colorado, and elsewhere ; amethyst at Bristol, R. I., and Keweenaw Point, Lake Superior ; chalcedony and agates of moderate beanty near Northampton, and along the trap of the Connecticut Valley-but finer near Lake Superior, upon some of the Western rivers, and in Oregon ; chrysoprase occurs at Belmont's lead mine, St. Lawrence County, N. Y., and a green quartz (often called chrysomrase) at New Fane, Vt., along with fine drusy quartz; red jasper occurs on the banks of the Hudson at 'Iroy; yellow josper is found with chalcedony at Chester, Mass. ; Hetiotrope occupies voins in slate at Bloomingrove, Orange County, N. Y.

Switzerland, Daphiny, Piedmont, the Carrara quarries, and numerous other forergn localities furnish fine crystals.

## Opal.

Compact and amorphous; also in reniform and stalactitic shapes; also earthy. Presents internal reflections, often of several colors in the finest varieties, exhibiting, when turned in the hand, a ich play of colors of delicate shades. Whate, yollow, red, brown. green and gray are some of the shades that verur, and mpure varieties are dark and opaque. Lustre subvitreons. $\quad I I=5 \cdot 5-6 \cdot 5 . \quad G .=1 \cdot 9-2 \cdot 3$.
('omposition. Opal consist.s of silica, like quartz; but it is silica in a different molecular state, the hardness and specifie gravity being less; and, besides this, it is soluble in astrong alkaline solution, especially if heated. It usually contains a few per cent. of water-anounting in some kinds to 12 per cent.; hut the water is not generally regrarded as an essential constituent.

## VARIETIES.

Precions: Opat. Extemal color usually milky, hat within there is a roch play of delicate tints. This variety forms a gem of rare beanty. A large mass in the imperial cabinet of Viemar weighs seventern ounces, and is nearly as large as a man's fist, but contains mumerous fissures and is not entirely disengaged from the matrix. This stone was well known to the ancients and highly valued by them. They called it P'aideros, or (Mild Beantiful as Love. The noble opal is found near Cashan in Mungary, and in Honduras, South America ; also on the Faroe lslands.

Fire Opat, Cioresol. An opal with yellow and bright hya-
cinth or fire-red reflections. It comes from Mexico and the Faroe Islands.

Common Opetl, Semional. Common opal has the hardness of opal and is casily scratched by quarta, a character which distinguishes it from some siliceous stones often called scmiopal. It has sometimes a milky opalescence, but does not reflect a phay of colors. The lustre is slighty resinons, and the colors are white, gray, red, yellow, hush, greenish to dark grayish-green. Translucent to nearly opaque. I'hillips found nearly o per cent. of water in one specimen.

Hydrophane. This rariety is opaque white or yellowish when dry, but becomes translucent and opaleseent when immersed in water.

Cucholmin. Opaque white, or hluish white, asd usually associated with chalcodony. Much of what is so called is nothing hat chalcedony; bat other specimens contain water, and are allied to hydrophane. It contains also a little alumina and allheres to the tongue. It was first brought from the river Carh in Bucharia.

Hyylitf, Muller's Giluss. A glassy transparent varicty, occurring in small concretions and occasmanly stabactitic. It rezemble somewhat a transparent gum arahic. Composition, Silica $92 \cdot(1)$, water (5:3) (Bucholz).
Menilite. A brown opaque variety, in compact reniform masses, occasionally slaty. Coumposition, silica ris:5, water $11 \cdot 0$ (Klaproth). It is found in slate at Menil Montime, near Paris.

Whool Opat. An impure opal, of a gras, hrown or hack color, having the structure of word, and looking much hike common silicified wood. It is wood pefrified with a hydrated silica (or opal), mstead of pure silica, and is distinguished by its lightness and inferior hardness. Specifie gravity, 2.

Opuil Jasper. Rescmilles jasper in appearance. and contains a few per cent. of iron ; but it is not so hard, owing to the water it contains.
Silicenus, Sinter has often the composition of opal, though sometimes simply frartz. The name is given to a loose, porons siliceous rock usually of a grayish color. It is depositad around the deysers of Iecland and the Yellowstone Park, in cellular or compact masses, sometimes in fibrons, stalactitic, or cauliflower-like shapes. It is often called yrysorite. P'carl sinter, or forite, occurs in valcanie tufa in
smooth and shining globular, botryoidal masses, having a pearly lustre.

Float Stone. A variety of opal having a porons and fibrous texture, and hence so light that it will float on water. It occurs in concretionary or tuberose masses, which often have a nucleus of quartz.

Tripolite, or Infusorial Earth. $\Lambda$ white or grayish-white earth, made mainly of siliccous secretions of microscope plants called Diatoms. It forms beds of considerable extent, and often occurs bencath peat. It is used as a polishing powder ; also to mix with nitroglycerine and make dynamite; and, owing to its poor conduction of heat, it is applied as a protection to steam boilers and pipes.

Tabasleer is a siliceous aggregation found in the joints of the bamboo in India. It contains several per cent. of water, and has nearly the apparance of hyalite.

Diff. Infusibility before the blowpipe is the best charactor for distinguishing opal from pitchstone, pearlstone, and other peecies it resembles. The absence of anything like cleavage or crystalline structure is another characteristic. Its inferior hardness and specific gravity separates it from quartz.

Obs. If ralite occurs sparingly at the Phillips ore hed, J'utnom Countr, N. Y., and in Jourke and Scriven counties, Georgit. In Washington County, Ga, good fire opal is obtained. The Suanna Spring in Georgia affords small quantities of siliceous sinter. Tripolite occurs in Maine, New Mampshire, Nevada, California, and elsewhere.

Tridymite. Pure silica. like quartz and opal, with very nearly the hardness and specific gravity of opal, but occurring in tabular hexagonal prisms, which are twins under the triclinic system. If not crystallized opal, it is a third state of $\mathrm{SiO}_{2}$. It occurs in trachytic and some wher volcanic rocks. Asmanite is from a metcorite, and may be the same as tridymite.

Ienzschite. Silica, $\mathrm{SiO}_{\mathrm{o}}$, in, it is supposed, a fourth state, it resembling opal in aspect and in solubility in alkaline solutions, but having the specific gravity of quartz, or $2 \mathbf{2}$. From Hüttenberg in Carinthia, resembling a white cachalong; from near Weissig; Regensberg ; and in Brazil.
Melanophlogite. Colorless cubes consisting of silica, with a little sulphuric trioxide and water. On sulphur from Girgenti, Sicily.

## II. SILICATES.

The silicates are here divided into the anhydrous and the hydrous.
In part of the anhydrous silicates, the combining value (or guantivalence, see page $7 \%$ ) of the silicon is to that of the basic elements as 2 to 1 ; in another part, as 1 to 1 ; and in a third division, as less-than-1 to 1 . On this ground the mineral silicates may be arranged in three groups, named reepectively: I. Bishlicates; JI. Unishlicates; and III. Subsilicates.
In the Pisilicates, one molecule of silicon is combined with one molecule of an element in the protoxide state, as Mg . Ca, Fe , etc., or one-third of a molecule of an element in the sesquiosite state, as Al, $\mathrm{Fe}, \mathrm{Mn}$, efe.; wr, what is the sane thing. 3 molecules of silicon, with 3 of an element in the protoside state, or 1 of an element in the sespuioxide state. The general formulas of such compounds is hence $\mathrm{IO}_{3} \mathrm{Si}$, or $\mathrm{RO}_{8} \mathrm{Si}_{2}$, or, if elements in both the protoxide and sesquioxide state are jresent, ( $\mathrm{R}_{3} \mathrm{R}$ ) $\mathrm{O}_{3}, \mathrm{Si}_{3}$, as explained on page 81.
In the Cinisilicates, ome molecule of silicon is combined with two of an element in the protoxide state, that is, for example, $\mathrm{Mg}_{2}, \mathrm{Ca}_{2}, \mathrm{Fe}_{2}$; or with two-thirds of a molecule in the sesquioxile state, that is, two-thirds of Al, Fu, Mn. The formula of these silicates is hence $\mathrm{h}_{9} \mathrm{O}_{4} \mathrm{Si}$, or $\mathrm{R}_{\frac{2}{3}} \mathrm{O}_{4}$ Si , or, in order to remove the fraction in the last, $\mathrm{He}_{2} \mathrm{O}_{12}$ Sis ; which becomes, when elements in the protoxide and sesquioxide state are both present, $\left(\mathrm{R}_{3}, \mathrm{R}\right)_{2} \mathrm{O}_{12} \mathrm{Si}_{3}$.
Among the species referred to the Unisilicates there are some that vary from the unisilicate ratio. This sccurs especially in species in which an alkali is prosent, as in the feldspars, micas, and scapolites.

The Subsilicates vary in the proportion of the silicon to the basic elements, and graduate into the unisilicates.

The same three grand divisions exist more or less satisfactorily among the hydrous silicates.

## A. ANHYDROUS SILICATES.

## I. BISILICATES.

The hisilicates, when the hase is in the protoxide state, and henee have the general formula $\mathrm{K}_{3}$ Si, are resolved in analyses into protoxides and silica in the ratio of 1120 to $1 \mathrm{Si} \mathrm{O}_{2}$, in which, as the term bisilicate implies, the oxygen of the silica is twiee that of the protoxides. If the base is in both the frotoxide and sespuioxide states, giving the formula $\mathrm{Re} . \mathrm{BO}_{9} \mathrm{Si}_{\mathrm{i}}$, the mineral is resolved in analyses into protoxides, sesquioxides and silicia. If the ratio of the protoxides to sesquioxides is $1: 1$. the formula will become $\frac{1}{2} \mathrm{R}_{3} \frac{1}{2} \mathrm{RO} \mathrm{O}_{,} \mathrm{Si}_{\text {; }}$ : and analyses give then, for the oxides and silica 3 RO , $1 \mathrm{FO} \mathrm{O}, 6 \mathrm{SiO} \mathrm{O}$.

Amons the following bisilicates the species from enstatite to spodumene and amphibole make a natural group called the hornblende, or hormblende and angite group. They are elosely related in composition and also in crystallization. The clearage prism is rhombic, and has either an angle of about $124 \frac{1}{2}^{\circ}$ or of about $83^{\circ}$; and the former of these two rhombic prisms has just twice the breadth of the other ; that is, if the lateral axis from the front to the back elve in each be taken atimity, the other lateral axis is twice as long in the prism of $1242^{\circ}$ as it is in that of $87^{\circ}$. The forms are either trimetric, monoclinic or triclinic ; and yet the close relations just stated exist between them. Enstatite is a magnesium or magnesium and iron species; wollastonite, : calcium species ; rhodonite, a manganese species ; pyroxene and hornhlende contain calcium with magnesium or iron; spodumene contairs lithium and aluminum, aluminum replacing the clements that in other species are in the protoxide state.

## Enstatite.

Trimetric. $\quad I \wedge I=S 8^{\circ} 16^{\prime}$. Prismatic cleavage easy. Usually possesses a fibrous appearance on the cleavage surface. Also massive and lamellar.

Color, grayish, yellowish or greenish-white, or brown. Lustre pearly ; often metalloidal in the bronzite variety. H. $5 \cdot 5 . \quad$ (.$: 3 \cdot 1-3 \cdot 3$.
( ${ }^{2}$ omposition. $\mathrm{Mg} \mathrm{O}_{3} \mathrm{Si}=$ Silica 60, marnesia 40. 13.13. infusible, and insoluble. Bronzite has a portion of the magnesium replaced by iron.

Itiff. Resembles amphibole and pyroxene, but is infusible, and trimetric in erystallization.
()bs. Occurs in the Vosues: Moravia; Bararia; Baste, in the Hartz; Leiperville and 'lexas, lit.; Mrewater's, N. Y.

Hypersthene is very near bronzite in crystalline form and in composition. It contains a larger percentage of iron, and on being heatol 3.B. on charcoal it becomes magnetic. Occurs at St. Paul's Island, in Labrador; Isle of Skye ; in Greenland ; Norway, etc.

## Wollastonite.-Tabular Spar.

Monoclinic. Rarely in obligue flat tened prisms. Usually massive, cleaving easily in one direction, and showing is lined or indistinctly columnar surface, with a vitreous lustre inclining to pearly.

Usually white, but sometimes tinged with yellow, red or brown. Translucent, or rarely subtransparent. Brittle. $\mathrm{H}=4 \cdot 5-5 . \quad \mathrm{G} .=2 \cdot 75-2 \cdot 9$.

Comporsition. $\mathrm{Ca}_{\mathrm{a}} \mathrm{O}_{3} \mathrm{Si}=$ Silica 52 , lime $4 R=100$. B.B. fuses with difficulty to a subtransurent, colorless glass; in powder decomposed by hydrochloric acid, and the solution gelatimizes on evaporation ; often effervesces when treated with acid on accomet of the presence of calcite.

Diff. Differs from ashestus and tremolite in its more viterous appearance and fracture, and by its gelatimizing in acid; from the zeolites by the absence of water, which all zeolites give in a closed tube ; from feldspar in the fibrous appearance of a cleavage surface and the action of acids.

Ots. Usually found in granite or granular limestone; occasionally in basalt or lava. Occurs in Ireland at I)unmore Ilead; at Vesurius and Capo di Bove; in the Hartz ; Hungary; Sweden; Finland; Norway.

At Willsboro', Lewis, Diana, and Roger's Rock, N. Y.,
of a white color, along with garnet; at Boonville, in bowlders with garnet and pyroxene ; Grenville, Lower Canada; in Bucks County, Pennsylvania; at Keweenaw Point, Lake Superior. Edelforsite is impure wollastonite.

## Pyrozene.-Augite.

Monoclinic. $I \wedge I=87^{\circ} 5$; cleavage perfect parallel with the sides of this prism, and also distinct parallel with the

diagonals. Tsually in thick and stout prisms, of 4,6 or 8 sides, terminating in two faces meeting at an edge. I I i-i $=133^{\circ} 333^{\prime}, / \wedge i-i=136^{\prime} 27^{\prime} ; 1 \wedge 1=120^{\circ} 32^{\prime}$. Massive varieties of a coarse lamollar structure ; also fibrous. fibres often very fine and offen long capillary. Also granular, usually in coarse gramular and friable masses ; grains usually angular ; sometimes round ; also compact massive.

Colors green of varions shades, verging to white on one side and brown and black on the other, passing through blue shades, but not yellon'. Lastre vitreons, inclining to resinous or pearly ; the latter especially in fibrous varieties.


Composition. R $\mathrm{O}_{3} \mathrm{si}$; in which R may be Ca, $\mathrm{Mg}, \mathrm{Fr}$, Mn, and sometimes $\mathrm{Zn}, \mathrm{K}_{2}, \mathrm{Na}_{2}$, these bases replacing one another without changing the crystalline form, of which two or more are usually present; the first three are most common. Calcium is always present. The following is an analysis of a typical variety: Silica 50.0 , lime $2 \cdot 5$, magnesia 165 , manganese protoxide 5 , iron protoxide $4 \cdot 5=100$. Fuses B.B., but its fusibility varies with the composition, and the ferriferous varieties are most fusible. Insoluble in acids.

Ififf. Its crystalline form, and its ready cleavage in two planes nearly at right angles to one another, are the best characters for its determination.

Varletres.-Tho varieties may be divided into three sec-
tions-the light colored, the dark colored, and the thin foliated.
I. Malacolite or white augite is a calcium magnesium pyroxene, and includes white or grayish-white crystals or crystalline masses. Dropside, of the same composition, occurs in greenish-white or grayish-green crystals, and cleavable masses cleaving with a bright smooth surface. Sahlite contains iron in addition, and is of a more dingy green color, has less lustre and coarser structure than diopside, but is otherwise similar: named from the place Sahla, where it oecurs. Fassaite contains a little alumina in addition to the clements of sahlite, and is found in crystals of rich green shades and smooth and lustrous exterior. The name is derived from the foreign locality Fassa. Coccolite is a general name for granular varietics, derived from the Greek coccos, gruin. The green is called green coccolite, the white, white coccolite. The specitic gravity of these varieties varies from $3 \cdot 25$ to $3 \cdot 3$.

Asbestus. This name includes fibrous varieties of both pyroxene and hornblende; it is more particularly noticed under the latter species, as pyroxene is rarely ashestiform.
II. Augite includes the black and greenish-black crystals, which contain a larger percentage of iron, or iron and magnesium, and which mostly present the form in figure 1. Specific gravity $3 \cdot 3-3 \cdot 4$. This is the common pyroxene of cruptive rocks. Hedenbergite. an iron-ealcium pyroxene, is a green-ssh-black opaque variety, in cleavable masses affording a greenish-brown streak; specific gravity 35. Polylite, Hudsonite, and Jeffersonite, fall here ; the last contains some zinc oxide. These varicties fuse more casily than the preceding, and the globule obtained is colored black by the iron oxide.
III. Diallaye is a thin-foliated varicty, often occurring imbedded in serpentine and some other rockz. It differs from bronzite and hypersthene in crystalline form, and in being fusible.

Obs. P'yroxene is one of the most common minerals. It occurs in almost all basic eruptive rocks, like doleryte, as an essential constituent, and is frequently met with in rocks of other kinds; common also in gramular limestone. In lasalt the crystals are generally small and black or greenish black. In the other rocks, they occur of all the shades of color given, and of all sizes to a foot or more in length. One crystal from Orange County, measured 6 inches in length, and

10 in circumference. White crystals occur at Canaan, Conn., Kingsbridge, New York County, and the Sing Sing quarries, Westchester Connty, N. Y.; in Orange County at several localities ; green crystals at Trumbull, Conn., at various places in Orange County, N. Y., Roger's Rock and other localities in Essex, Lewis, and St. Lawrence counties. Dark green or black crystals are met with near Edenville, N. Y., Diana, Lewis County. Jeffersonite occurs at Franklin, in N. J. Green coccolite is found at Roger's Rock, Long Pond, and Willsboro', N. Y.; black coccolite, in the forest of Dean, Orange County, N. Y. Diopside, at Raymond and Rumford, Me., Hustis's farm, Phillipstown, N. Y.

P'yroxene was thus numed by IIä̈y from the Greek pur, fire, and xenos, stranger, in allusion to its occurring in lavas, where, according to a mistake of Naüy, it did not belong. 'The name Augite is from the (areek auge, lustre.

Black to greenish black in color. It is a pyroxene containing nearly 10 per cent. of soda, and much iron sesquioxide. From near Brevig in Norway, Ilot Springs, Arkansas.
Acnite.: In long highly-polished prismu, of a dark-brown or reddishbrown color, with a pointed extremity, penetrating granite, near Kongsberg in Norway. $I \wedge I=86^{\prime} 56^{\prime}$, resombles pyrozene. Contains over 12 per cent. of soda. Fuses easily before the blowpipe.

Bahingtonite. Resembles some varieties of pyroxene. It occurs in greenish black splendent crystals in quartz at Arendal in Norway.

Uralite. Has the form of pyroxene but cleavage of hornblende.

## Rhodonite.-Manganese Spar, Fowlerite.

Triclinic, but rery nearly ismmorphous with pyrosene. Usually massive, the clearage ofton indistinct.

Color reddish, usually deep flesh-red ; also brownish, greenish, or yellowish, when impure ; very often black on the surface ; streak uncolored. Lustre vitreous. Transparent to opaque. Becomes black on exposure. II. $=55-6 \cdot 5$. $\mathrm{G} .=3 \cdot 4-3 \%$.

Composition. $\mathrm{MnO}_{3} \mathrm{Si}=$ Silica $45^{\circ} \cdot 9$, manganese protoxide $54 \cdot 1=100$. It usmally contains a little iron and lime repacing the manganese. Becomes dark brown when heated, and, with borax in the outer flame, gives a deep violet color to the bead white hot, and a red-hrown when cold.

Diff. Resembles somewhat a flesh-red feldspar, but differs in greater specific gravity, in blackening on long exposure, and in the glass with borav.

Obs. Occurs in Sweden, the Hartz, Siberia, and else-
where. In the United States it is found, in masses, at Plainfield and Cummington, Mass. ; also abundantly at Hinsdale, and on Stony Mountain, near Winchester, N. H.; at Blue Hill Bay, Me. The black exterior is a more or less pure hydrated oxide of manganese.

Rhodonite may be used in making a violet-colored glass, and also for a colored glazing on stoneware. It receives a high polish and is sometimes employed for inlaid work.

## Spodumene.

Monoclinic. $I \wedge I=8^{\pi}$, being near the angle of pyroxene. Clearage easy, parallel to $I$ and $i-i$. Surtace of clearage pearly. Color grayish or greenish. Translucent to subtranslucent. $\quad H .=6 \cdot 5-\% \quad$ (.$=3 \cdot 1-3 \cdot 19$.

Composition. ( $\mathrm{R}_{3}, \mathrm{Al}$ ) $\mathrm{O}_{9}, \mathrm{Si}_{3}$, in which R is lithium and equals $\mathrm{Li}_{2}$, and $3 \mathrm{Li}_{2}$ is to Al as $1: 4$. This corresponds to silica $64 \%$, alumina $29 \cdot 4$, lithia $6 \cdot 4=100$. B.B. hecomes white and opaque, fuses. swells up, and imparts to the flame the purple-red flame of lithia. Unaffected by acids.

Ififf. Resembles somewhat feldspar and seapolite, but has a higher specific gravity and a more pearly lustre, and affords rhombic prisms by cleavage. Its lithia reaction is its most characteristic test.

Obs. Occurs in gramite at Coshen ; also at Chesterfield, Norwich and Sterling, Mass. ; at Windham, Me. ; at Brookfield, Ct. It is found at. Uton, in Sweden; Sterzing in the Tyrol; and at Killiney Bay, near Dublin.

This mineral is remarkable for the lilhia it contains, and has been used for obtaining this rare earth.

## Petalite.

Monoclinic. Usually in imperfectly cleavable masses; most prominent cleavage angle $141^{\circ} 30^{\prime}$. Color white or gray, or with pale-reddish or greenish shades. Lustre vitreous to sub-pearly. Translucent. $H=6-6.5$. $1 .=2 \cdot 5$.

Composition. Contains lithia like spodumene, and gives the percentage-Silica $7 \% \cdot 9$, alumina $1 \% \cdot \%$, lithia $3 \cdot 1$, soda $1 \cdot 3=100$. Phosphoresces when gently hoated. Fuses with difficulty on the edges. Gives the reaction of lithia like spodumene.

Diff. Its lithia reaction allies it to spodumene, but it
differs from that mineral in lustre, specific gravity, and greater fusibility.

Obs. From Utö, Sweden ; also from Elba (Castor or Castorite).

```
Amphibole.-Hornblende.
```

Monoclinic. $I \wedge I=124^{\circ} 30^{\prime}$. Cleavage perfect parallel with $I$. Often in long, slender, flat rhombic prisms (fig. 2), breaking easily transversely; also often in 6 -sided prisms, with oblique extremities. Frequently columnar, with a bladed structure; long fibrous. the fibres coarse or fine and often like flax, with a pearly or silky lustre; also lamellar; also gramular, either coarse or fine.

Colors from white to black, passing through bluish-green, grayish-green, green,
 and brownish-green shades, to black. Instre vitreous, with the deavage face inclining to pearly. Nearly transparent to opaque. $\quad \mathrm{II}=5-6 . \quad \mathrm{G} \cdot=2 \cdot 9-3 \cdot 4$.

Composition. R $0_{3} \mathrm{Si}$, as for pyroxene. R may correspond to two or more of the basic clements $\mathrm{Mg}, \mathrm{Ca}, \mathrm{Fe}, \mathrm{Mn}$, $\mathrm{N} \mathrm{a}_{2}, \mathrm{~K}_{2}$, the first three being most common. Aluminum is very often present in amphibole. replacing a portion of the silicon. The blowpipe characters are like those of pyroxene. It fuses, but the fusibility varies indefinitely, being casiest in the black varieties.

Diff. It is distinguished by the very ready cleavages parallel to a prism of $1242^{\circ}$, while pyroxene cleaves at noarly a right angle ( $87^{\circ} 5^{\prime}$ ).

This species, like pyroxene, has numerons varieties, differing much in external appearance, and arising from the same causes-isomorphism and crystallization.

The following are the most important varieties:

## I. LIGHT-COLORED VARIETIES.

Tremolite, Grammatite. Tremolite comprises the white and grayish crystallizations which usually occur in blades or long erystals penetrating the gangue or aggregated into coarse columnar forms. Sometimes nearly transparent. $\mathrm{G} .=2 \cdot 9$. Formula $(\mathrm{Ca}, \mathrm{Mg}) \mathrm{O}_{3} \mathrm{Si}=$ Silica $57 \cdot 70$, magnesia $28 \cdot 85$, lime $13 \cdot 45=100$. The name is from the foreign locality, Tremola, in Switzerland.

Actinolite. The light-green varieties. It is a magnesium-
calcium-iron amphibole. Glassy actinolite includes the bright glassy crystals, of a rich green color, usually long and slender, and penetrating the gangue like tremolite. Radiated actinolite includes olive-green masses, consisting of aggregations of coarse acicular fibres, radiating or divergent. Avbestiform actinolite resembles the radiated, but the fibres are more delicate. Massive actinolite consists of angular grains instead of fibres. $G .=3 \cdot 0-3 \cdot 1$. The name actinolite alludes to the radiated structure of some varieties, and is derived from the Greek, aktin, a ray of the sun.

Asbestus. In slender fibres casily separable, and sometimes like flax. Either green or white. Amiunthus, includes fine silky varieties. (Much so called is serpentine; serpentine is hydrous, and is thereby casily distinguished.) Ligniform asdestus is compact and hard; it occurs of brownish and yellowish colors, and looks somewhat like jetrified wood. Mountain leather occurs in thin, tough sheets, looking and fecling a little like kid leather; it consists of interlaced fibres of ahestus, and forms thin scams between layers or in fissures of rocks. Mountain cork is similar, but is in thicker masses; it has the elasticity of cork, and is usually white or grayish white.

The preceding light-coiored rarjeties contain little or no alumina or iron.

Composition of glassy actinolite : Silica $59 \cdot 75$, magnosia $21 \%$, lime $14 \cdot 25$, protuxide of iron $3 \cdot 9$, protoxide of manganese $0 \cdot 3$, hydrofluoric acid 0.8 (Bonsdorf).

Nephrite is a very tough compact varicty, related to tromolite. Color light-green or blac. It breaks with a splintery fracture and glistening lustre. $\mathrm{H} .=6-6 . \mathrm{b} . \mathrm{G} .=3$. It is a magnesium-calcium amphibole. Nephrite is made into images, and was formerly worn as a charm. It was supposed to be a cure for discases of the kidney, whence the name, from the Cireck, nephros, kidney. In New Zealand, China and Western America, it is carved by the inhahitants, or pollished down into various fanciful shapes. It is called jade; Wut the aluminum-sodium silicate, called jardeite, is the stone most highly prized of all those that are called jade. Much of the mineral from China called jade is prehnite.

## II. DARK-COLORED VAKIETIES.

Cummingtonite is a magnesium-iron amphibole. Color gray or brown; usually fibrous. Named from the locality where found, Cummington, Mass.

Pargasite. Dark-green crystals, short and stout (resembling fig. 4), with bright lustre, of which Pargas in Finland is a noted locality. G. $=3 \cdot 11$.

Composition. Silica 45.5 , alumina 14.9 , iron protoxide $8 \cdot 8$, manganese protoxide $1 \cdot \overline{0}$, magnesia $14 \cdot 4$, lime $14 \cdot 9=$ 100.

Hornblende. Black and greenish-black crystals and massive specimens. Often in slender crystallizations like actinolite ; also short and stout like figs. 4 and 5, the latter more especially. It contains a large percentage of iron oxide, and to this owes its dark color. It is a tough mineral, as is implied in the name it bears. This character, however, is best seen in the massive specimens. Pargasite and hornblende contain both alumina and iron.

Composition of a hornblende: Silica $48 \cdot 8$, alumina 7.5 , magnessia $13 \cdot 6$, lime $10 \cdot 2$, iron protoxide $18 \cdot 8$, manganese protnside $1 \cdot 1=100$.

Obs. Hormblende is an essential constituent of certain rocks, as syenyte, dioryte and hornhlende schist. Actinolite is usually found in magnesian rocks, as tale. steatite or serpentine ; tremolite in granular limestone and dolomite ; asbestus in the abore rocks and also in serpentine. Back crystals of hornblende occur at Franconia, N. II., Chester, Mass., 'Thomastown, Me., Willsboro', N. Y., in Orange County, N. Y., and elsewhere. Pargasite occurs at Phippsburg ind Parsonsfich, Me.; glassy actinolite, in steatite or tale, at Windham, Readshoro', and New Fane, Vt., Middlefield and Blandford, Mass.; and radiated varieties at the same localities and many others. Tremolite and gray hornblende occur at Camain, Ct., Lee, Newburgh, Mass., in Thomaston and Raymond, Me., lover, Kingshridge, and in St. Lawrence County, N. Y. ; at Chestrint Hill, Pemn. ; at the Bare Mills, Md. Asbestus at many of the abore localities: also Brighton and Sheffield, Mass.; Cotton Rock and Ilustis's farm, Phillipstown, N. Y., noar the Quarantine, Richmond County, N. Y. Mountain leather is met, with at Brunswick, N. J. Edenite, a whito aluminous kind, occurs at Edenville, N. Y.
Asbestus is the only varicty of this species of any use in the arts. The flax-like varicty is sometimes woren into fire-proof textures. Its incombustibility and slow condaction of heat render it a complete protection against the flames. It is often made into gloves. A fabric when
dirty, need only be thrown into the fire for a few minates to be white again. The ancients, who were acquainted with its properties, are said to have used it for napkins, on account of the ease with which it was clemed. It was also the wick of the lamps in the ancient temples; and because it maintained a perpetual flame without being consumed, they named it asbestos, unconsumed. It is now used for the same purpose by the natives of Greenland. The name amianthus alludes to the ease of cleaning it, and it is derived from amiantos, undefiled. Asbestus is cxtensiyely used for lining iron safes, and for protecting steam pipes and boilers. The best locality for collecting asbestus in the Thited States is that near the Quarantine, in Richmond County, N. Y.

Anthophyllite is related in the angle of its prism to hornblende, but is trimetric. In composition and its infusibility before the blowpipe, it is near bronzite. B.B. it becomes magnetic. From Kongsberg in Norway, and near Modum. Kupfferite has the hornblende angle, but in composition it is like enstatite, being a magnesium silicate.
Arfve lismite. Near hornblende; but coutains over 10 per cent. of sida, like acmite.

Crociddlite. Near arfvedsonite in composition. A lavender-blue or leek-green fibrous mineral from Orange River, Nouth Africa, and from the Vosges ; also from Phode Island (A. H. Chester).

Gastatite. $A$ dark blue to azure-blue mineral related to amphibole, from the valleys of Aosta and Locano.

Glaurophane. A bluish mineral with the amphibole angle, from the Island of Syra. Wichtisite, may be the same mineral.

Milarite. Trimetric, of the composition ( KH ) $\mathrm{Ca}_{2} \mathrm{AlO}_{32} \mathrm{Si}_{12}$; the quantivalent ratio for bases and silica $1: 4$; being thercfore a quatersilicate instead of a bisilicate.

## Beryl.-Emerald.

Hexagonal. In lexagonal prisms, usnally without regular terminations. Cleavage basal, not very distinct.
 Rarcly massive.

Color green, passing into blue and yellow ; color rather pale, excepting the deep and rich green of the emerald. Streak uncolored. Lustre vitreous; sometimes resinous. Transparent to subtranslucent. Brittle. H. $=7 \cdot 5-8$. G. $=$ $2 \cdot 65-2.75$.
Varieties. The emerald is the rich green variety ; it owes its color to the presence of chromium. Beryl includes the paler varieties, which are colored by oxide of iron. Aqua-
marine includes clear beryls of a sea-green, or pale-bluish or bluish-greon tint.

Composition. $\mathrm{Be}_{3} \mathrm{Al} \mathrm{O}_{18} \mathrm{Si}_{6}=$ Silica $66 \cdot \mathrm{~S}$, alumina $19 \cdot 1$, glucina $14 \cdot 1=100$. Emerald contains less than one per cent. of chromium oxide. 13.13. becomes clouded, but does not fuse; at a very high temperature the elges are rounded. Unacted upon by acids.

Diff. The hardness distinguishes this species from apatite; and this character, and also the form of the erystals, from green tourmaline.

Obs. The finest emeralds come from Muso, ncar Simata Fé in New (irenada, where they occur in dolomite. A crystal from this locality, $2 f$ inches long and about $a$ inches in cumeter, is in the cabinet of the Duke of Demomshire; it weighs 8 oz. 18 dwts., and is a regular hexagonal prism. A more splendid specimen, but weyghing only 6 oz., in the possession of Mr. Hope, of London, cost $£ 500$. Emeralds of less beauty, but of gergantic size, oceur in sibema. One apecimen in the royal collection of linssan masures $4 \frac{1}{2}$ inches in length and 12 in breadth, and weighs $163^{3}$ pounds troy. Another is 7 inches long and 4 broad, and weighs 6 poinds. Mount Zalora in Upper Egypt affords a less distinct variety.

The fincst beryls (aquamarines) come from Siberia, Hindostan and Brazil. One specimen belonging to 1)om Pedro is as large as the head of a calf, and weighs 20.5 ounces, or more than 18, pounds troy ; it is transparent and withont a flaw. In 1827 a fine aquamarine, weighing 35 grams, was found in Siberia, which is said to have been ralued at 600,000 francs.

In the United States, beryls of enormous size have been obtained, but seldom transparent erystals. They oceur in granite or gneiss. One hexagonal prism from Crafton, N . H. weighs 9,900 pound and measured 4 feet in length, with one diameter of 32 inches and another of 22 ; its color was bluish green, excepting a part at one extremity, which was dull green and yellow. At Royalston, Mass., one crystal has been ohtained a foot long, and pellucid crystals are sometimes met with. Haddam, Comn., has afforded fine erystals (see the figure). Other localities are Bare, Fitchburg, Goshen, Mass.; Albany, Norwich, Bowdoinham and Topham, Me.; Wilmot, N. II.; Monroe, Fortland, Haddam, Conn.; Leiperville, Penn.

Phenacite. A beryllium-silicate, rhombohedral in crjstallization. From the Urals, and Durango in Mexico.

Eudialyte. A pale rose-red mineral, from West Greenland, occurring in rhombohedral crystals, and containing $15 \cdot 6$ per cent. of airconia. Eucolite is a related species from Norway.

Pollucite. An isometric resium silicate, white, vitreous in lustre, with $G=2.868$. Analysis afforded Rammelsberg Silica $48 \cdot 15$, ulumina 1631 , potash 0.47 , soda $2 \cdot 48$, casium oxide $30 \cdot 00$, water $259=100$, giving very nearly the bisilicate formula $\mathrm{H}_{2} \mathrm{Cs}_{2} \mathrm{AlO}_{20} \mathrm{Si}_{6}$. From Elba.

## II. UNISILICATES.

For the convenience of the student, the general formulas of the regular Unisilicates are here re-stated. They are as follows:

If the base is in the protoxide state alone, the formmla is $\mathrm{R}_{2} \mathrm{O}_{4} \mathrm{Si}$, in which R stands for $\mathrm{Ca}, \mathrm{Mg}, \mathrm{Fe}, \mathrm{Mn}, \mathrm{K}_{2}, \mathrm{Na}_{2}$, or $\mathrm{Li}_{2}$, or other mutually replaceable base. In analyses, the mineral is resoled into protoxides and silica, in the ratio of 2 RO to $\mathrm{SiO}_{2}$, in which the oxygen of the silica equals that of the basic portion.

If the base is in the sesquioxide state alone, the formula is $\mathrm{R}_{2} \mathrm{O}_{12} \mathrm{Si}_{3}$, in which H may stand for Al, Fe , or Mn, cte. Ilere the mineral is resolved, in analyses, into sespuioxides and silica in the ratio of $2 \mathrm{H}_{3}$ to $3 \mathrm{Si} \mathrm{O}_{2}$, in which the oxygen of the silica again equals that of the basie portion.

If the basic fortion is partly in the protoxide state and partly in the sesquioxide, the formula, in its most general form, is $\left(\mathrm{R}_{3}, \mathrm{R}\right)_{2} \mathrm{O}_{12} \mathrm{Si}_{3}$. In this formula the ratio of $\mathrm{R}_{3}$ to If is not stated. If the ratio is $1: 1$, the formula becomes $\mathrm{H}_{3} \mathrm{If}^{2} \mathrm{O}_{12} \mathrm{Si}_{3}$. or its equivalent $\left(\frac{1}{2} \mathrm{I}_{3} \frac{1}{2} \mathrm{R}\right)_{2} \mathrm{O}_{12} \mathrm{Si}_{3}$. In a case like this last, the mineral is resolved, in analyses, into protoxides, sesquioxides and silica, in the ratio of $3 \mathrm{RO}: \mathrm{He}_{3}: 3 \mathrm{Si} \mathrm{O}_{2}$, in which again the oxygen of the bases equals that of the silica.

If the proportion of $R_{3}$ to $\mathbf{R}$ is $1: 3$, this corresponds to $\frac{1}{3} \mathrm{R}_{3}: \mathrm{R}$, or, its equivalent, $\mathrm{R}: \mathrm{R}$; and hence the formula in its general form will be $\operatorname{RR} \mathrm{O}_{8} \mathrm{Si}_{9}$.

If the base is in the dioxide state, the formula becomes $\mathrm{R}_{4} \mathrm{Si}$, an example of which occurs in zircon, whose formula is $\mathrm{ZrO}_{4} \mathrm{Si}$.

There are several natural groups of species among the Unisilicates.

```
GROUP.
```

1. Chrysolite group,
2. Willemite group,
3. Garnet group,
4. Zircon group,
5. Idocrase and Scapolite groups,
6. Mica group,
7. Feldspar group,

In the Scapolite, Mica and Feldspar groups part of the species contain an alkaline metal in the hasic portion, and such kimds haw ererally an excess of silica. Among the feldspars, the sueeses containing only calcium as the protoxide base, is a true Unisilicate. In the others, there is an excess directly proportional to the increase of the soda, as explained beyond.

## Chrysolite.-Olivine.

Trimetric. In rectangular prisms having clearage parallel with $i$-h. Tsually in imbedded grains of an olivegreen color, looking like green bottle-glass. Also yellowish green. Tramsparent to tramslucent. H. $=0-\% \quad$ ix. $=33$ -35 . Looks much like glass in the fracture, exeept in its having cleavage.

Composition. ( $\mathrm{Mg}, \mathrm{Fe})_{2} \mathrm{O}_{4} \mathrm{Si}=$, for a common variet:, Silica $41: 39$, magnesia $50 \cdot 90$, iron protoxide $7 \cdot 71=100$. Tho amount of iron is variable. B.B. whitens but is infusible. With borax forms a yellow bead owing to the iron present. Decomposed by hydrochloric acid, and the solution gelatinizes when evaporated. Hyalosillerite is a very ferruginous variety which fuses B.B.

Diff. Distinguished from green quartz by its occurring
disseminated in basaltic rocks, which never so occurs; and in its cleavage. From obsidian or volcanic glass it differs in its infusiblity.

Obs. Occurs as a rock formation: also disseminated through basalt and other eruptive rocks, and is in characteristic mineral of some varieties of them. Ilas been found in New Hampshire, Canada, and elsewhere. As a rock it oceurs in North Carolima, and l'ennsylvania. It also oceurs in many meteorites. Boltonite, from limestone at Bolton, Mass., is a variety of chrysolite.

Sometimes used as a gem, but it is too soft to be valued, and is not delicate in its shade of color.

Forsterite is a magnesian chrysolite $\mathrm{Mg}_{2} \mathrm{O}_{4} \mathrm{Si}$; Frayalite, an iron chrysolite, $\mathrm{Fe}_{2} \mathrm{O}_{1} \mathrm{Si}$; Monticellite, a calcium-magnesium, $\mathrm{CaMg}_{2} \mathrm{O}_{1} \mathrm{Si}$; Ilurtonolite, an iron-magnesium chrysolite from Orange County, N. Y ; Rippperitc, an irou-manganese-zinc chrysolite from Stirling Hill, N.J.; Tephroite, a manganose chrysolite $\mathrm{Mn}_{2} \mathrm{O}_{2}$ Si, from Stirling Hill, N. J.; Kucbelite, a manganese-iron chrysolite, MnFe $\mathrm{O}_{\mathrm{Si}} \mathrm{Si}$, from Dannemora, Sweden.

Leucophanite and meliphanite are species containing the element glucinum (beryllium), the former greenish yellow and $\mathrm{G}=2 \cdot 97$, the latter yellow and $\mathrm{G}=3 \cdot(18$. From Norway.

Wöllerite contains zirconium, and also columbium ; color light yellow. $\quad \mathrm{G}=3 \cdot 41$.

Willemite is a zinc unisilicate, $\mathrm{Zn}_{2} \mathrm{O}_{4} \mathrm{Si}$. See page 157.
lhoptese is a copper silicate, which, making the water basic, is a unisilicate, $\mathrm{H}_{2} \mathrm{CuO}_{4} \mathrm{Si}$. See page 141 .

Frielclute is a rose-red manganese silicate of the general formula $\mathrm{R}_{2} \mathrm{O}_{4} \mathrm{Si}$, in which IR consists of manganese and hydrogen in the atomic ratio 2:1.

Helvitc (Helvin). Isometric ; in tetrahedral crystals. Color honeyyellow, brownish, greenish. Lustre vitreo-resingus. H. $=\mathbf{= 6 - 6 \%}$. $\mathrm{a} .=3.133$. Contains manganese, iron, and glucinum, and some sulphur. From Saxony, and Norway.

Danalite. Isometric; in octahedral crystals. Color flesh-red to gray. Lustre vitreo-resinous. $\mathrm{H}=5.5 \mathrm{a}=3 .=327$. Contains zinc, gluciumm, iron, manganese. Found disseminated through the granite at Rockport, Cape Ann, Mass., and also near Gloucester, Mass.

E'ulytite is a bismuth silicate, and Bismutoferritc a bismuth-andiron silicate.

## Garnet.

Isometric. Common in dodecahedrons (fig. 1), also in trapezohedrons (fig. ©2), and both forms are sometimes variously moditied. Cleavage parallel to the faces of the dodecahedron; sometimes rather distinct. Also found massive granular, and coarse lamellar.

Color deep red to cinnamon color ; also brown, black, green, emerald-green, white. Transparent to opaque. Lustre vitreous. Brittle. $\mathrm{H} .=6 \cdot 5-7 \cdot 5 . \quad \mathrm{G} .=3 \cdot 1-4 \cdot 3$.


Composition and Turicties. The general formula for the species is ( $\left.\mathrm{R}_{3} \mathrm{R}_{2}\right)_{2} \mathrm{O}_{12} \mathrm{Si}_{3}$; in which R may be calcium, magnesium, iron, manganese, and If may be aluminum, iron, chromium. The varieties owe their differences to the proportions of these clements, or the substitution of one for another. Most garnets fuse easily to a brown or black glass ; but the fusibility varies with the constituents, and chromegarnet is infusihle. They are not decomposed by hydrochloric acid ; but if first ignited, then pulverized and treated with acid, they are decomposed, and the solution usually gelatinizes when evaporated.

There are three series among the varieties: one, that of alumina-garnot, in which the sesquioxide base is chiefly aluminum ; the second, that of iron-rarnet, in which the sesquioxide base is chicfly iron instead of aluminum ; and third, chrome-garnet, in which it is chromium.

## I. Alumina-(garnet.

Almandite (Almandine). An iron alumina-garnet, $\mathrm{Fe}_{3}$ $10_{12} \mathrm{Si}_{3}=$ Silica $36 \cdot 1$, alumina $20 \cdot 6$, iron protoxide $433=$ 100. It occurs of various shades of red from ruby-red and hyacinth-red, to columbine-red and brownish red. When transparent it is called prerious garnet ; and, if not so, common garnet.

Grossularite (including Cinnamon Stone). A lime alu-mina-gurnet, $\mathrm{Ca}_{3} \mathrm{Al}_{12} \mathrm{Si}_{3}=$ Silica $40 \cdot 1$, alumina $22 \cdot \%$, lime $37 \cdot 2=100$, but often with some iron protoxide in place of part of the lime. The name Grossularite was given to a pale-green garnet, in allusion to the color, from the Latin name for gooseberry. Cinnamon Stone includes the cinna-mon-colored variety.

Pyrope. A magnesia alumina-garnet $\mathrm{Mg}_{3} \mathrm{Al}_{12} \mathrm{Si}_{3}$. Color deep red, but varying to black and green.

Spessartite. A manganese alumina-garnet ( $\mathrm{Mn}, \mathrm{Fe})_{\mathrm{s}} \mathrm{Al}$ $\mathrm{O}_{12} \mathrm{Si}_{3}$, some iron replacing part of the manganese. Color red, brownish red, hyacinth-red. A Haddam specimen afforded Seybert, Silica $35 \cdot 8$, alumina, $18 \cdot 1$, iron protoxide $14 \cdot 9$, manganese protoxide $31 \cdot 0$.
II. Iron-Garnet.

Andradite. $\Lambda$ lime iron-marnet, $\mathrm{Ca}_{8} \mathrm{Fe}_{1_{12}} \mathrm{Si}_{3}$. Colors rarious, from that of almandite or common garnet, to a wine-yellow, as in Topazolite; green, as in Jelletite; and black, as in Melanite and Pyreneite.

Colophonite is a dark-red to brownish-yellow coarse granular garnet having often iridescent hues.
Aplome is a red variety. Rothoffite has manganese in place of part of the lime, and a yellowish-brown to reddish-brown color.

Ytter-garnet contains yttria in place of part of the lime.
Bredbergite. A lime-magnesia iron-garnet.
III. Chrome-Garnet.

Ouvarovite. An cmerald-green lime chrome-garnet ( Ca , $\mathrm{Mg})_{3} \mathrm{Fe}_{\mathrm{O}} \mathrm{O}_{12} \mathrm{Si}_{3} . \quad \mathrm{G} .=3 \cdot 41-3 \cdot 42$.
Diff. The vitreous lustre of fractured garnet, and its usual dodecahedral forms, are casy characters for distinguishing it.

Obs. Garnet occurs abundantly in mica schist, hornblende schist, and gneiss, and somewhat less frequently in granite and granular limestone; sometimes in serpentine; occasionally in trap, and other igneous rocks.
The best precious garnets are from Ceylon and Greenland ; cinnamon stone comes from Ccylon and Swoden; grossularite occurs in the Wilui River, Siberia, and at Tellemarken in Norway; green garnets are found at Schwartzenberg, Saxony ; melanite, in the Vesuvian lavas; ouvarovite, at Bissersk in Russia; topazolite, at Mussa, Piedmont.
In the United States, precious garnets, of small size. occur at Hanover, N. H.; and a clear and deep red variety, sometimes called pyrope, comes from Green's Creek, Delaware County, Penn. Dodecahedrons. of a dark red color, occur at Haverhill and Springfield, N. H., some $1 \frac{1}{2}$ inches through; also at New Fane, Vt., still larger ; at Unity, Brunswick, Streaked Mountain, and elsewhere, Maine ; at Monroc, Lyme and Redding, Conn.; Bedford, Chesterfield,

Barre, Brookfield, and Brimfield, Mass.; Dover, Dutchess County, Roger's Rock, Crown Point, Essex County, N. Y.; Franklin, N. J. Cinnamon-colored crystals occur at Carlisle, Mass., transparent, and also at Boxborough ; with idocrase at Parsonsfield, Phippsburg and Rumford, Me.; at Amherst, N. H. ; at Amity, N. Y., and Franklin, N. J.; at Dixon's Quarry, seven miles from Wilmington, Del., in fine trapezohedral crystals. Melanite is found at Franklin, N. J., and Germantown, Penn. Chrome garnet is found in Orford, Cimadia. C'olophonite is abundant at Willsborough and Lewis, Essex County, N. Y. : it occurs also at North Madison, Conn.

The garnet is the carbuncle of the ancients. The alahandic carhuncles of Pliny were so called becanse cut and polished at Alabanda, and hence the name Almandine now in use. The girnet is also supposed to have been the hyacinth of the ancients.

The clear deep-red garnets make a rich gem, and are much used. Those of Pegu are most highly valued. They are cut quite thin, on account of their depth of eolor. The cinnamon stone is also employed for the same purpose. Pulverized gitnet is sometimes employed as a substitute for emery.

Pliny describes ressels, of the capacity of a pint, formed from large carbuncles, "devoid of lustre and transparency, and of a dingy color," which probably were large garnets.

## Zircon.

Dimetric. $J \wedge I=132^{\circ} 10^{\prime} ; 1 \wedge 1=123^{\circ} 19^{\prime}$. Cleavare parallel to 1 , but imperfect. Usually in crystals ; but also gramular.


Color brownish red, brown, and red, of clear tints; also yellow, gray, and white. Streak uncolored. Lustre more or less adamantine. Often transparent; also nearly opaque. Fracture conchoidal, brilliant. $\quad I I=7 \cdot 5 . \quad(\hat{y} .=4 \cdot(0-4 \cdot 8$.

Composition. $\mathrm{Zr} \mathrm{O}_{4} \mathrm{Si}=$ Silica 33, zirconia $6 \%=100$. B. B. infusible, but loses color.

Varieties. Transparent red specimens are called hyacinth. A colorless variety from Ceylon, having a smoky tinge, is called jargon; it is sold for inferior diamonds, which it resembles, though much less hard. The name zirconite is sometimes applied to crystals of gray or brownish tints.
Jiff. Zircon is readily distinguished from species which it resembles in other properties by its square prismatic form, specific gravity, and adamantine lustre.

Obs. The zircon is confined to crystalline rocks, occurring in granite, gneiss, granular limestone, and some igneous rocks. Zircon-syenyte is a syenyte with disseminated zircons. Zircon often occurs in auriferous sands. Hyacinth occurs mostly in grains in such sands, and comes from Ceylon, Auvergne, Bohemia, and elsewhere in Europe. Siberia affords crystals as large as walnuts. Splendid specimens come from Greenland.
In the United States, fine crystals of zircon occur in Buncombe County, N. C. ; of a cinnamon-red color in Moriah, Essex Countr, N. Y. ; also at Two Ponds and elsewhere, Orange County, in crystals sometimes an inch and a half long ; in Hammond, St. Lawrence County, and Johnsbury, Warren County, N. Y. ; at Franklin, N. J. ; in Litchfield, Me.: Middlebury, Vt. ; in Canada at Grenville, cte.

The name hyacinth is from the fireek huakinthos. But it is doubtful whether it was applied by the ancients to stones of the zircon species.
The clear crystals (hyacinths) are of common use in jewelry. When heated in a crucible with lime, they lose their color, and resemble a pale straw-ycllow diamond, for which they are substituted. Zircon is also used in jeweling watches. The hyacinth of commerce is to a great extent cinnamon stone, a variety of garnet. The carth zirconia is used as an adrantageons substitute for lime in the oxyhydrogen lantern.

[^3]
## Vesuvianite.-Idocrase.

Dimetric. $0: 1=142^{\circ} 46^{\prime} ; 1 \wedge 1=129^{\circ} 21^{\prime}, 1: i-i=127^{\circ}$ 14'. Cleavage not very distinct parallel with $I$. Also found massive granular, and subcolumnar.


Color hrown ; sometimes passing into green. In some varicties the color is oil-green in the direction of the axis and yellowish green at right angles with it. Streak uncolored. Lustre vitreous. Subtransparent to nearly opaque. $\mathrm{H} .=6 \cdot 5 . \quad(\mathrm{X} .=3 \cdot 33-3 \cdot 4$.

Composition. $\left(\frac{4}{7} \mathrm{Ca}_{3}, \frac{3}{7} \mathrm{Al}\right)_{2} \mathrm{O}_{12} \mathrm{Si}_{3}$. A small part of the Ca is usually replaced hy magnesium, and part of the aluminum sometimes by iron in the sesquioxide state. Percentage of a common variety, Silica $37 \cdot 3$, alumina $16 \cdot 1$, iron sesquioxide $3 \cdot \%$, lime 354 , magnesia $2 \cdot 1$, iron protoxide $2 \cdot 9$, water $2 \cdot 1=99 \cdot 6$. B.B. fuses easily with effervescence to a greenish or brownish globule.

Diff. Resembles some brown varieties of sarnet, tourmaline and epidote, but besides its difference of crystallization, it is much more fusible.

Obs. Vesuvianite was first found in the lavas of Tesuvins, and hence the name. It has since been obtained in Piedmont; near Christiania, Norway; in Siberia; also in the Fassa Valley. Cyprine includes blue erystals from Tellemarken, Norway : supposed to be colored by copper.

In the United States, it occurs in fine crystals at Phippsburg and Rumford, Sandford, Parsonsfield and Poland, Me.; Newton, N. J.; Amity, N. Y. In Canada at Calumet Falls, and at Grenville.

The name idocrase is from the Greek cido, to see, and krasis, mixture ; because its crystalline forms have much resemblance to those of other species.

This mineral is sometimes cut as a gem for rings.
Mellilite in honey-ycllow crystals (which includes Hum-
boldtilite) is a related dimetric species, from Capo di Bove, near Rome, and Mount Somma, Vesuvius.

## Epidote.

Monoclinic. $i-i \wedge 1 i=115^{\circ} 24^{\prime}$. $i-i \wedge-1-i=110^{\circ} 18^{\prime} .-1 \wedge$ $-1=109^{\circ} 3 \tilde{r}^{\prime}$. Cleavage parallel to
 $i-i$; less distinct parallel to $1-i$. Also massive gramular and forming rock masses ; sometimes columnar or fibrous.

Color yellowish green (pistachiogreen) and ash-gray or hair-brown. Streak meolored. Translucent to opaque. Lastre vitreous, a little pearly on $i-i$; often brilliant on the faces of cerstals. Brittle. II. $=6-\% . \quad \mathrm{G} .=3 \cdot 25-3 \cdot 5$.

Composition. A lime iron-alumina silicate, the iron being mostly in the sesquioxide state and replacing aluminum. Percentage of common variety, Silica $37 \cdot 83$, alumina $22 \cdot 63$, ron serguioxide $15 \cdot 0$, iron protoxide $0 \cdot 93$, lime $23 \cdot 27$, water $2 \cdot 05=100 \cdot \% 3$.
B.B. epidote fuses with effervescence to a black glass which usually is magnetic. Partially decomposed by hydrochloric acid, but if first ignited, is then decomposed, and the solution gelatinizes on evaporation.

Green epidote is often called Pistacite. Piedmontite is a variety containing much manganese, of reddish-brown or reddish-black color.

Bucklandite is an iron-cpidote.
Diff. The peculiar yellowish-green color of ordinary epidote distinguishes it at once. From zoisite and vesuvianite it differs in fusing to a black magnetic globule.

Obs. Oecurs in crystalline rocks, especially in hornblendic rocks. It often occurs in the cavities of amyodaloidal rocks. Splendid crystals, six inches long, and with brilliant faces and rich color, have been obtained at ILaddam, Ct. Crystallized specimens are also found at Franconia, N. H., Hadlyme, Chester, Newbury and Athol, Mass.; near Unity, Amity, and Monroc, N. Y.; Franklin and Warwick, N. J.; Pennsylvania, at E. Bradford; Michigan, in the Lake Superior region ; Canada, at St. Joseph.

The name epidote was derived by Haïy from the Greek epididomi, to increase, in allusion to the fact that the base of the primary is frequently much enlarged in the crystals.

Zoisite. A mineral of the epidote group, occurring in trimetric crystals, with $I \wedge I=116^{\circ} 40^{\prime}$, and having a white, pale-grayish, palegreenish to reddish color ; also massive. H. $=6-6 \cdot 5$. G. $=3 \cdot 1-3 \cdot 4$.

It is a lime-epidote, with little or no iron. B.B. swells up and fuses to a white blebby glass; after ignition, gelatinizes with hydrochloric acid. Thulite is a rose-red variety. Occurs at Saualpe in Carinthia, in the Tyrol ; Arendal, etc.; in Vermont at Willsboro' and Montpelier ; in Massachusetts, at Goshen, Chesterfield, ctc.; in Pennsylrania at Unionville, and in Tennessee at the Ducktown copper mine.

Saussurite, from the euphotide of the Alps in the vicinity of Lake Geneva, approaches zoisite in composition, it affording Hunt Silica $43 \cdot 59$, alumina $27 \cdot 72$, iron sequioxide $2 \cdot 61$, magnesia 2.98 , lime $19 \cdot 71$, water 0.35 , soda $3.08=100.04$. Color whitish, greenish gray, ash-gray; $\mathrm{G} .=3226-3 \cdot 385 . \mathrm{H} .=65-7$. The saussurite of Orezza gave nearly the same composition in an analysis by Boulanger, and that of Schwartzwald in general the same, with more of magnesia and less of lime, in an analysis by Hütlin. The high specific gravity separates it from scapolite (wernerite) which it resembles in composition, and also from the feldspar group.

Jadecte, one of the kinds of pale-green stones used in China for ornaments, called feitsui, has the high specific gravity of zoisite, but it has nearly the composition of oligoclase, if the iron and magnesia be excluded; analysis by Damour affording Silica $50 \cdot 17$, alumina $22 \cdot 58$, iron protoxide $1 \cdot 56$, magnesia $1 \cdot 15$, lime $2 \cdot 68$, soda $12 \cdot 93=10007$. It is the material of some of the oruaments in the Swiss lake-dwellings.

Allanite.-A cerium epidote, of a pinchbeck-brown to brownishblack and black color, submetallic to pitch-like and resinous in lustre, crystallizing in the monoclinic system, and with the angles nearly of epidote. H. $=5 \%-6 . \quad$ (.$=3-4 \%$.
B.B. fuses easily and swells up to a dark, blebby magnetic glass. Most varieties gelatinize with hydrochloric acid, but not after ignition. Found in Norway, Sweden, Greenland, Scotland; at Snarum, near Dresden ; in Massachusets, at the Bolton quarry ; in New York, at Moriah in Fssex County, Monroe in Orange County ; in New Jerser, at Franklin ; in Pennsylvania, at East Bradford and Eatun ; in Virginia, Amherst County ; in Canada, at St. Paul's.

Orthite is a variety in long slender crystals. Muromontit', Bodenite, and Michallonite are related minerals.

Gadolinite. A mineral of a greenish-black color, containing lithium, cerium, and harium, from Sweden, Greenland, and Norway. Crystals monoclinic, with $I \wedge I=116^{\prime} . \quad \mathrm{II} .=6 \cdot 5-7 . \quad$ G. $=4-4 \overline{5}$.

Mosandrite. Reddish-brown to dull greenish or yellowish-brown silicate of cerium, lanthanum and didymium, calcium, and titanium. $\mathrm{H}=4$. G. $=2 \cdot 9-3 \cdot 03$. From Brevig, Norway.
llvaite (Yenitc). In trimetric striated prisms, of an iron-black to grayish-black color. $I \wedge I=112^{\circ} 38^{\prime} . \mathrm{H}=5 \cdot 5-6 . \quad \mathrm{G} .=3 \cdot 7-4 \% . \quad$ In composition a calcium-iron silicate in which part of the iron is in the sesquioxide state. From Elba; Fossum and Skeen in Norway, etc. Also reported as occurring at Cumberland, R. I., and Milk Row quarry, in Somerville, Mass. The name Ilraite is derived from the Latin name of the lsland of Elba.

## Axinite.

Triclinic. In acute-cdged oblique rhomboidal prisms; $P \wedge r=134^{\circ} 45^{\prime}, r \wedge u=115^{\circ} 38^{\prime}, P \wedge u=135^{\circ} 31^{\prime}$. Cleavage indistinct. Also rarely massive or lamellar.

Color clove-brown ; differing some-
 what in shade in three directions, being trichroic. Lustre vitreons. Transparent to subtranslucent. Brittle. H. = $6 \cdot 5-7 . \quad$ G. $=3.27 . \quad$ Pyro-electric.

Composition. A unisilicate, affording boron trioxide, and containing boron among its bases. One analysis afforded Silica $43 \cdot 68$, boron trioxide $5 \cdot 61$, alumina $15 \cdot 63$, iron sesquioxide $9 \cdot 45$, manganese sesquioxide $3 \cdot 05$, lime $20 \cdot 92$, magnesia $1 \% 0$, potash $0 \cdot 64=$ $100 \cdot 43$. 13.13. fusos casily with intumescence to a dark-green or black glass, imparting a pale-green color to tho flame, which is due to the boron.

Diff. Remarkable for the sharp thin edges of its crystals, and its glassy brilliant appearance, without clearage. The crystals are implanted, and not disseminated like garnet. In one or all of these particulars, and also in blowpipe reaction, it differs from any of the titanium ores.

Obs. Occurs at St. Cristophe in Dauphiny ; at Kongsberg in Norway; Normark in Sweden ; Santa Maria, in Switzerland ; Cornwall, England ; Thum in Siaxony, whence the name Thummerstein and Thumite.

In the United States it has been found at Phippssburg and Wales in Maine ; and at Cold Spring, New York.

Danburite. A silicate which contains, like axinite, boron trioxide. Composition: Silica $48 \%$, boron trioxide 285 , lime 24.7 . Occurs with oligoclase and orthoclase in inbedded masses of a pale-yellow color, at Danhury, Conn. $H .=7 . \quad$ G. $=2 \cdot 95-2 \cdot 90$.

## Iolite.-Dichroite. Cordierite.

Trimetric. In rhombic prisms of $120^{\circ}$, and in 6 and 12sided prisms. Also massive. Cleavage indistinct; but crystals often separable into layers parallel to the base, especially after partial alteration.

Color various shades of bluc, looking often like a pale or
dark blue glass ; often deep blue in direction of the axis, and yellowish gray trausversely. Streak uncolored. Lustre vitreous. Transparent to translucent. Brittle. H. $=7-7 \cdot 5$. G. $=2 \cdot 6-2 \cdot \%$.

Composition. A silicate of aluminum, magnesium and iron, corresponding to Silica $49 \cdot 4$, alumina $33 \cdot 9$, magnesia $8 \cdot 8$, iron protoxide $7 \cdot 9=100$. B. B. loses its transparency and with much difficulty fuses.

Diff. The glassy appearance of iolite is so peculiar that it can be confounded with nothing but blue quartz, from which it is distinguished by its fusing on the edges. It is easily scratched by sapphire.

Obs. Found at Haddam, Conn., in granite ; also in gnciss at Brimfield, Mass.; at Richmond, N. H., in talcose rock. The principal foreign localities are at Bodenmais in Bavaria; Arendal, Norway; Capo de Gata, Spain; Tunaberg, Finland ; also Norway, Creenland and Ceylon.

The name iolite is from the Greek ion, violet, alluding to its color ; it is also called dichroite, from dis, twice, and chroa, color, owing to its having different colors in two directions.

Occasionally employed as an ornamental stone, and is cut so as to present different shades of color in different directions.

Iolite exposed to the air and moisture undergoes a gradual alteration, becoming hydrous, and assuming a foliated micaceous structure, so as to resemble talc, though more brittle and hardly greasy in feel. Hydrous Iolite, Fahlunite, Chlorophyllite, and Esmarkite, are names that have been given to the altered iolite ; and Gigantolite and a number of other like miverals are of the same origin. (See p. 315.)

## MICA GROUP.

The minerals of the mica group are alike in having (1) their crystals monoclinic ; (2) the front plane angle of the base, or of the clearage laminæ, $120^{\circ}$; (3) clearage emjnent, parallel to the base, affording very thin laminæ; and (4) aluminum and potassium among the essential constituents. The combining or quantivalent ratio for the bases and silicon is usually 1 to 1 in Biotite, Phlogopite, and Lepidomelane; 1 to more than 1 in Muscovite, Lepidolite, etc.

The ordinary light-colored micas are mostly Muscovite, and the black, mostly Biotite. Lepidolite is a light-colored mica containing lithia ; and Lepidomelane a black mica containing more iron than biotite. Muscovite and biotite are so closely related that crystals of the latter often occur that are finished out uninterruptedly by muscovite, the axial lines of the one continuous with those of the other; and such crystals are sometimes several inches across. There is here a compound structure chemically, but no twinning in the crystallization. When a thin plate of mica is struck with a pointed awl or other tool a symmetrical star of six rays is produced, the rays being clearage lines parallel to the sides of the rhombic prism $I$ and the shorter dagonal.

## Biotite.

Monoclinic. Crystals usually short crect rhombic or hesngonal prisms. Common in disseminated scalcs; also in masses made up of an aggregation of scales.
Color dark green to black, rarely white. Transparent to opaque. Lustre more or less pearly on a cleavage surface. Optic-axial angle usually less than $1^{\circ}$; crystals appear often to be uniaxial. H. $=2 \cdot 5-3$. G. $=2 \cdot 7-3 \cdot 1$.

Composition. Mostly ( $\mathrm{K}_{2}, \mathrm{Mg}, \mathrm{Fe}_{3}$, $\mathrm{Al} \mathrm{O}_{12} \mathrm{Si}_{\mathrm{c}}$, a raricty afforded Silica $40 \cdot 91$, alumina $17 \cdot \% 9$, iron oxides 10.00 , magnesia 19.04 , potash 9.96 . B. B. whitens and fuses on thin edges; sometimes the flame is red owing to the presence of a little lithium.

Lepillomelane. Like biotite, but containing more iron oxides and less of magnesia than biotite, and folia brittle. Fuses easily to a black magnetic globule. Annite (from Cape Ann, Mass.) is near Lepidomelane.
Pllogopite. Contains much magnesia and little or no iron. Color yellowish brown te brownish red, somewhat copper-like in its reffections ; also white or colorless. Optic-axial angle $3^{\circ}$ to $20^{\prime}$. H. $=2.5-3$. G. $=2 \cdot 78-2 \cdot 85$. In crystals and scales in granular limestone. From Gouverneur, Edwards, and other places in Northern New York; Stirling Mine, and Newton, N. J.; St. Jerome, and Burgess, Canada ; in the Vosges. Aspidolite, from the Tyrol, is a rulated mica.
Astrophyllite. A bronze-yellow mica affording nearly 8 per cent. of titanium dioxide. From Brevig, Norway, and El Paso County, Colorado.

## Muscovite.-Common Mica.

Monoclinic. In oblique rhombic prisms of about $120^{\circ}$. Crystals commonly have the acute edge replaced, as in the accompanying figure (plane $i-i$ ). Usually in plates or scales. Sometimes in radiated groups of aggregated scales or small folia.

Colors from white through green, yellowish and brownish shades ; rarely rose-red. Lustre more or less parly. Transparent or translucent. Tough and elastic. $\mathrm{H} .=2-2 \cdot 5 . \quad \mathrm{G} .=2 \cdot \%-3$.
 Optic-axial angle $44^{\prime}$ to $78^{\circ}$.

Composition. A common variety afforded Silica $46 \cdot 3$, alumina $36 \cdot 8$, potash $9 \cdot 2$, iron sesquioxide $4 \cdot 5$, fluoric acid $0 \cdot \%$, water $1 \cdot 8=99 \cdot 3$. Often contains 3 to 5 per cent. of water, and thus passes to a hydrous mica called Margarodite. (See page 313). B.B. whitens and fuses on the thinnest edges, but with great difficulty, to a gray or yellow glass.

A variety in which the scales are arranged in a plumose form is called plumose mica; another, in which the plates have a transverse cleavage, has been termed prismatic mica.
I)iff. Differs from tale and gypsum in affording thinner and much tougher folia, and in being clastic ; but muscovite when hydrous loses its elasticity, and becomes more pearly in lustre.

Obs. Muscovite i.: a constituent of granite, gneiss and mica schist, and gives to the latter its schistose structure. It also occurs in gramular limestonc. Plates two and three feet in diameter, and perfectly transparent, have been obtained at Alstead, and Grafton, New Hampshire, and it has been mined at these places, and in Orange and elsewhere. Other good localities are Paris, Mc.; Chesterfield, Barre, Brimfield, and South Royalston, Mass.; near Greenwood Furnace, Warwick and Edenville, Orange County, and in Jefferson and St. Lawrence counties, N. Y.; Newton and Franklin, N. J.; near Germantown, Pa.; Jones’s Falls, Maryland. Obliquo prisms from near Greenwood are sometimes six or seven inches in diameter. Western North Carolina affords much mica for commerce.

A green variety occurs at Unity, Maine, near Baltimore, Md., and at Chestnut Hill, Pa. Prismatic mica is found at Rassel, Mass.
On account of the toughness, transparency, and the thinness of its folia, mica was formerly used in Siberia for glass in windows, whence it has been called Muscovy glass. It is in common use for lanterns, and also for the doors of stoves, and other purposes which demand a transparent substance not affected by heat.

Lepidolite, or Litiia mica. Resembles muscovite. Color rose-red, and lilac to white; in crystalline plates and aggregations of scalos. lt contains from 2 to 5 per cent. of lithia, and hence B.B. imparts a deep crimson color to the flame.

From Rozena in Moravia; Zinnwald in Bohemia (the Zinnucaldite); Saxony ; the Ural ; Sweden; Cornwall; Paris, and Hebron, Maine; Chesterfield, Mass.; Middletown, Conn. The red mica of Goshen is muscovite.

C'ryophyllite has the same constituents as lepidolite. It fuses easily in the flame of a candle. From Cape Ann, Mass.

## SCAPOLITE GROUP.

The Scapolite species are dimetric in crystallization, usually white in color or of some light shade, and analyses afford alumina and lime with or without soda. The lime scupolites are unisilicate in ratio ; the others, containing alkali, have, with one exception, more silica than this ratio requires.

Wernerite.-Scapolite
Dimetric. $1: 1=136^{\circ} 7^{\prime}$. Cleavage rather indistinct parallel with $i-i$ and $I$. Also massive, sub-
 lamellar, or sometimes faintly fibrous in appearance.

Colors light; white, gray, pale blue, greenish or reddish. Streak uncolored. Transparent to nearly opaquc. Lustro usually a little pearly. H. $=5-6$. G. $=$ $2 \cdot 6-2 \cdot 8$.

Composition. $\left.\left(\frac{1}{3}\left(\mathrm{Ca}, \mathrm{Na}_{3}\right)\right)_{3}^{2} \mathrm{Al}\right)_{2} \mathrm{O}_{12} \mathrm{Si}_{3}=$ Silica $48 \cdot 4$, alumina 28.5 , lime $18 \cdot 1$, soda $5 \cdot 0=100$. B.B. fuses easily with intumescence to a white glass. Imperfectly decomposed by hydrochloric acid.

Diff. Its square prisms and the angle of the pyramid at summit are characteristic. In cleavable masses it resembles foldspar, but there is a slight fibrous appearance often distinguished on the cleavage surface of scapolite, which is peculiar. It is more fusible than feldspar, and has higher specific gravity. Spodumene has a much higher specific gravity, and differs in its action before the blowpipe. Tabular spar is more fibrous in the appearance of the surface, and is less hard; it also gelatinizes with acids.

Obs. Found mostly in the older crystalline rocks, and also in some volcanic rocks. It is especially common in granular limestone. Fine crystals occur at Gouverncur, N. Y., and at Two Ponds and Amity, N. Y.; at Bolton, Boxborough and Littleton, Mass.; at Franklin and Newton, N. J. It occurs massive at Marlboro', Vt.; Westfield, Mass.; Monroe, Ct. Forcign localities are at Arendal, Norway ; Warmland, Sweden; Pagas in Finland, and also at Vesuvius, whence come the small crystals called meionite.

Nuttallite, Claucolitc, are varicties of this species.
Elkebergite resembles wernerite, being distinguishable from it only by chemical analysis. Dipyre also is near wernerite, but contains more silica and 10 per cent. of soda; from the Pyreneets.

Meionite, a lime scapolite, is like werncrite in its crystals, but has the formula ( $\left.{ }_{3}^{1} \mathrm{Ca}_{3} \mathrm{Al}_{2}\right)_{2} \mathrm{O}_{12} \mathrm{Si}_{3}$, being a true unisilicate. From Monte Somma.

Mizzonite and Marialite resemble meionite. Paranthine and Sarcolite are other related unisilicate species.

## Nephelite.-Nepheline.

Hexagonal. In hexagonal prisms with replaced basal edges; $O \wedge 1=135^{\circ} 55^{\prime}$. Also massive ; sometimes thin columnar.

Color white, or gray, yellowish, greenish, bluish-red. Lustro vitreous or greasy. Transparent to opaque. II. $=$ $5 \cdot 5-6 . \quad$ G. $=2 \cdot 5-2 \cdot 65$.

Composition. $\left(\mathrm{Na}_{2}, \mathrm{~K}_{4}\right) \mathrm{Al} \mathrm{O}_{8} \mathrm{Si}_{2}=$ (if $\mathrm{Na}: \mathrm{K}=5: 1$ ) Silica $44 \cdot 2$, alumma $33 \cdot \%$, soda $16 \cdot 9$, potash $5 \cdot 2=100 ;$ a little lime is usually present. B.B. fuses quietly to a colorless glass. Decomposed by hydrochloric acid, and the solution gelatinizes on cvaporation. The name nephelite alludes to the mineral becoming clouded in acid. Nephelite includes the glassy crystals from Vesuvius called Sommite, and also hexagonal crystals in other volcanic rocks; and a massive variety, of greasy lustre, called Elowolite, from the Greek
elaion, oil. Altered crystals are in part the mineral Gieseckite.

Diff. Distinguished from scapolite and feldspar by the greasy lustre when massive, and its forming a jelly with acids ; from apatite by the last character, and also its hardness.

Obs. Nephelite is the prominent constituent of nephelindoleryte or nephelinyte, and phonolyte, and oceurs also in some other eruptive rocks; and it also enters into the constitution of miascyte, zircon-syenyte, metamorphic rocks. Among the localities are Vesuvius and C. di Bove, in Italy; Katzenbuckel, near INeidelberg; Aussig in Bohemia; and as elæolite, Brevig, Norway; in Siberia; in the Ozark Mountains, Arkansas ; in Litchficld, Maine.

Cancrinite. Crystals like those of nephelite, and composition similar, except the presence of some carbonates and usually water. Color white, gray, yellow, green, blue, or reddish; $H .=5-6 . \quad(\mathrm{x} .=2 \cdot 4-2 \cdot 5 . \quad$ On account of the carbonates it efferresces in acids. B.B. fuses very easily.

Occurs in crystalline rocks at Miack in the Ural ; in Norway; Transylvania; and at Litchfield in Maine, with elæolite and sodalite. Supposed to be altered nephelite.

Microsommite is near. Sommite (nephelite).

## Sodalite.

Isometric. In dodecahedrons; cleavage dodecahedral. Color brown, grar, or blue. $\mathrm{H} .=\mathrm{G}$. G. $=2 \cdot 25-2 \cdot 3$.

Composition. $\mathrm{Na}_{2} \mathrm{Al} \mathrm{O}_{8} \mathrm{Si}_{2}+1 \mathrm{NaCl}=$ Silica $37 \cdot 1$, alumina $31 \cdot 7$, soda $19 \cdot 2$, sodium $4 \cdot 7$, chlorine $7 \cdot 3=100$. B. B. fuses with intumescence to a colorless glass. Decomposed by hydrochloric acid, and the solution gelatinizes on evaporation.

Occurs in cruptive and metamorphic rocks. Found in Sicily ; near Lake Laach ; at Miask; in Norway ; West Greenland ; of a blue color at Litchfield, Me.; and lavender-blue at Salem, Mass.

Haüynite (or Hauyne) and Nosite (or Nosean) are related minerals from lavas or other eruptive rocks; and Ittnerite is altered haüynite or nosite. Isometric. In dodecahedrons. Color bright blue, occasion. ally greenish. Transparent to translucent. II. $=6$. G. $=2 \cdot 4-2 \cdot 5$.

Lapis-Lazuli.--Ultramarine.
Isometric. In dodecahedrons; cleavage imperfect. Usually massive. Color rich Berlin or azure blue. Lustre vitreous. Translucent to opaque. $\mathrm{H} .=5 \cdot 5 . \quad \mathrm{G} .=2 \cdot 3-2 \cdot 5$.

Composition. Silica $45 \cdot 5$, alumina $31 \cdot 8$, soda $9 \cdot 1$, lime $3 \cdot 5$, iron $0 \cdot 8$, sulphuric acid $5 \cdot 9$, sulphur $0 \cdot 9$, chlorine $0 \cdot 4$, water $0 \cdot 1=98 \cdot 0$. B.B. fuses to a white translucent or opaque glass, and if calcined and reduced to powder loses its color in acids; is decomposed with the evolution of hydrogen sulphide, and the solution gelatinizes on evaporation. The color of the mineral is supposed to be due to sodium sulphide. The mineral is not homogeneous, but the exact nature of the ultramarine species at the basis of it is not yet ascertained.

Obs. Found in syenyte and granular limestone, and is brought from Persia, China, Siberia, and Bucharia. The specimens often contain scales of mica and disseminated pyrites.

The richly-colored lapis-lazuli is highly esteemed for costly vases, and for inlaid work in ornamental furniture. It is also used in the manufacture of mosaice. When powdered it constitutes a beautiful and durable blue paint, called Ultramarine, which has been a costly color. The discovery of a mode of making an artificial ultramarine, quite equal to the native, has afforded a substitute at a comparatively cheap rate. This artificial ultramarine consists of silica $45 \cdot 6$, alumina $23 \cdot 3$, soda $21 \cdot 5$, potash $1 \cdot 7$, lime trace, sulphuric acid $3 \cdot 8$, sulphur $1 \cdot \%$, iron $1 \cdot 1$, and chlorine a small quantity undetermined. It has taken the place in the arts, entirely, of the native lapis-lazuli.

## Leucite.-Amphigeno.

Dimetric. Form rery nearly that of the trapezohedron represented in the figure. Clearage imperfect. Usually in dull glassy crystals, of a grayish color; sometimes opaque-white, disseminated through lava. Translucent to opaque. $\mathrm{H} .=5 \cdot 5-6 . \quad \mathrm{G} .=2 \cdot 5$. Brittle.

Composition. $\mathrm{K}_{2} \mathrm{Al} \mathrm{O}_{12} \mathrm{Si}_{1}=$ Silica $55 \cdot 0$, alumina $23 \cdot 5$, potash $21 \cdot 5=100$. B. B. infu-
 sible. Moistened with cobalt nitrate and ignited assumes a blue color. Decomposed by hydrochloric acid, without gelatinizing.

Diff. Distinguished from analcite by its hardness and infusibility.

Obs. In volcanic rocks, and abundant in those of Italy,
cspecially at Vesuvius, where crystals occur from the size of a pin's head to a diameter of an inch. Also found in the Leucite Hills, northwest of Point of Rocks, Wyoming Territory.

The name leucite is from the Greols leukios, white.

## FELDSPAR Group.

## I. Relations of the Species of Felispar.

The species of the Feldspar Group are related-
A. In crystallization: (1) the forms being all oblique; (2) the angle of the fundamental rhombic prism $I$, in each, nearly $120^{\circ}$; (3) the other augles differing but little, although part of the species are monoclinic and part triclinic ; and (4) there being two directions of casy cleavage, one, the most perfect, parallel to the basal plane $O$, and the other parallel to the shorter diagonal section, with the intervening angle either $90^{\circ}$ (as in the monoclinic species orthoclase and hyalophane), or nearly $90^{\circ}$ (as in the triclinic species).
B. In composition: (1) the only element in the sesquioxide state being aluminum, and those in the protoxide state either calcium, barium, sodium, or potassium, or two or three of these bases together; (2) the ratio of 1 atom of $\mathrm{P}_{0}$ to 1 of R being constant ; (3) the amount of silica in the species increasing with the proportion of alkali, being that of a unisilicate in the pure lime-feldspar, anorthite, that of a tersilicate in the soda-feldspar, albite, or potash-feldspar, orthoclase, and so directly proportioned to the alkali, that the amount in any lime-and-soda feldspar may be deduced by taking the lime (or calcium) as existing in the state of a unisilicate, and the soda in that of a tersilicate, and adding the two together.

Anorthite has the formula $\mathrm{CaAl} \mathrm{O}_{8} \mathrm{Si}_{\mathrm{y}}$.
Allite " " $\mathrm{Na}_{2} \mathrm{Al} \mathrm{O}_{18} \mathrm{Si}_{6}$.
The constitution of a species containing Ca and $\mathrm{Na}_{8}$ in the ratio of 1 to 1 for the protoxide portion may be ob-
tained as follows. Adding together the anorthite and albite formulas, we have $\mathrm{CaNa}_{2} \mathrm{Al}_{2} \mathrm{O}_{24} \mathrm{Si}_{8}$; then dividing by 2 , the formulas becomes $\frac{1}{2} \mathrm{Cad}_{2} \mathrm{Na}_{2} \mathrm{AlO}_{12} \mathrm{Si}_{4}$, which expresses the composition of andesite. With 3 parts of the Ca unisilicate, and 1 of the $\mathrm{N} a_{2}$ tersilicate, the composition is that of labradorite. So it is for other combinations, that is for other species between anorthite and albite in composition.

The quantivalent ratio for the R , Al, Si, in the several species of the group, is as follows: V means triclinic in crystallization, and IV monoclinic.


These are the normal ratios; but there is some variation from them in the analyses, part of which is variation in actual composition, and part a result of interlamination or mixture of two feldspars together. Thus, orthoclase occurs mixed with microcline, albite, or oligoclasc. But while such mixtures account for the soda found in some analyses of orthoclase, it does not for that in all, since soda does occur in many specimens of pure orthoclase, replacing part of the potash. It is the same with the triclinic feldspar microcline, which has the composition of orthoclase, and may have the alkali portion all potash or part soda, one analysis of typical microcline giving only $0 \cdot 48$ of soda. It is, hence, not safe to calculate the percentage of orthoclase present in a feldspar from the percentage of potash. Moreover, potash is present in much albite.

The above ratios show that anorthite has for the ratio between $\mathrm{R}+\mathrm{R}$ and $\mathrm{Si}, 4: 4$, or $1: 1$, as in true unisilicates; while in albite and orthoclase, the same ratio is $4: 12$ or 1:3, that of a tersilicate, as above stated.
C. In physical characters: the hardness being between 6
and 7; the specific gravity, between 2.44 and $2 \cdot 75$; lustro vitreous, but often pearly on the face of perfect cleavage; and each species transparent to subtranslucent.

## II. Actidic and Basic Feldspars.

Oligoclase, albite, and orthoclase are called acidic feldspars, because of the large amount of the acidic element, silicon, in their constitution, analyses giving 60 to 70 per cent. of silica; and labradorite and anorthite are called basic feldspars, the amount of silica being 42 to 55 per cent. Correspondingly, eruptive, and metamorphic rocks in which either of the acidic feldspars is a prominent con-stituent-for example, granite, gnciss, trachyte, true por-phyry-are called acidic rocks; while those rocks in which basic feldspars are constituents-like doleryte, and a large part of cruptive rocks-are called basic rocks.
III. Distinctions of the Triclinic Feldspars.

The triclinic feldspars are distinguished from the monoclinic (e.g. orthoclase) by the occurrence of very fine striations on the cleavage surface, sometimes too fine to be seen without a good pocket-lens. These striations are due to multiple twinning parallel to the other cleavage face, as explained on page 57. They are rarely absent from triclinic feldspar crystals. They are best brought out by transmitted polarized light, in which a transverse section of the crystal is seen banded with spectrum colors, each band corresponding to one plate of the twin structure.
The triclinic feldspars, andesite excepted, may be distinguished from one another by an optical method when the cleavage direction can be made out. For this purpose a plate is prepared parallel to the plane of easiest cleavage. In such a plate the multiple twinning is parallel to the other cleavage plane, or the shorter diagonal. When the plate is placed on the stage of a polariscope, between crossed Nicolprisms, as the stage is revolved, the adjoining bands of color become dark alternately, and the angle through which the
plate has to be revolved for the change between consocative bands varies for different species, it being $54^{\circ}$ to $74^{\circ}$ for anorthite, $10^{\circ}$ to $14^{\circ}$ for labradorite, $4^{\circ}$ to $8^{\circ}$ for oligoclase, $6 \frac{1}{2}^{\circ}$ to $8^{\circ}$ for albite, and $30^{\circ}$ for microcline. The shorter diagonal of the crystal bisects this angle, so that the angle made with this diagonal is $27^{\circ}$ to $37^{\circ}$ for anorthite, $5^{\circ}$ to $7^{\circ}$ for labradorite, $2^{\circ}$ to $4^{\circ}$ for oligoclase, $3 \frac{1}{2}^{\circ}$ to $4^{\circ}$ for albite, and $15^{\circ}$ for microcline. Obtaining cleavage plates for such measurements in the case of slices for microscope investigation, is seldom possible, and when not so, the only certain resource for the distinguishing of triclinic feldspars is chemical analysis. These feldspars have been called plagioclase (from the Greek words for oblique and fracture), as if all were of one species. The term is a convenient cover for ignorance.
IV. Distinctions from otier Minerals. When in crystals, the form is sufficient to determine a feldspar ; so also the fact of two unequal cleavages inclined to one another at $84^{\circ}$ to $90^{\circ}$, one of them quite perfect. No fibrous, columnar, or micaccous varicties are known. They differ from rhodonite, by the absence of a manganese reaction ; from spodumene, by the absence of a lithia reaction as well as cleavage angles; from scapolite, by form, the cleavage angles, the more difficult fusibility ; from nephelite, by form, and also in difficult fusibility, and not gelatinizing with acids, except in the case of anorthite and labrudorite, which fuse with but little more difficulty than nephelite, and often will gelatinize.

## Anorthite.-Indianite. Lime Feldspar.

Tricinic. Angle between the two cleavage planes $85^{\circ} 50^{\prime}$ and $94^{\circ} 10^{\prime}$. Crystals tabular. Also massive granular or coarse lamellar. Color white, grayish, or reddish.

Composition. CaAl $\mathrm{O}_{8} \mathrm{Si}_{2}=$ Silica $43 \cdot 1$, alumina $36 \cdot 8$, lime $20 \cdot 1=100$. B.B. fuses with much difficulty to a colorless glass ; decomposed by hydrochloric acid, the solution gelatinizes on ceaporation.

Obs. Occurs in basic cruptive rocks; also in some meta-
morphic rocks. Found in the lava of Vesuvins; in the Tyrol ; Faroe Islands, Iceland ; in imbedded crystals in some doleryte of the Connecticut Valley.

At Hanover, N. H., anorthite crystals occur altered to a silicate which afforded, in an analysis by Hawes, only 22 of lime, and, in place of the rest of this ingredient, $7 \cdot 11$ of potash, $3 \cdot 77$ of soda, $1 \cdot 10$ of ironsesquioxide, and 2.67 of water, with 3005 of alumina and 52.52 of silica; which compound, if the water be made basic, has the ratio nearly of labradorite, though distinct from that species in the alkalies, and also in specific gravity, which is 296 or very nearly 3 . It has some relation to zoisite, and to typical saussurite, but is widely different in constituents and ratio; it is related also to jadeite. (See page 263.)

Labradorite.-Lime-soda Feldspar. Labrador Feldspar.
Triclinic. Angle between the cleavage planes $93^{\circ} 20^{\prime}$ and $86^{\circ} 40^{\prime}$. Usually in cleavable massive forms.

Color dark gray, brown, or greenish brown ; also white or colorless. Often a series of bright chatoyant colors from internal reflections, especially blue and green, with more or less of yellow, red, and pearl-gray.

Composition. $\mathrm{Ca}_{4} \mathrm{Na}_{5} \mathrm{Al} \mathrm{O}_{10} \mathrm{Si}_{4}=$ Silica $52 \cdot 9$, alumina $30 \cdot 3$, lime $12 \cdot 3$, soda $4 \cdot 5=100$. Sometimes contains a little potash in place of the soda. B.B. fuses quite easily to a colorless glass. Only partially decomposed by hydrochloric acid.

Obs. A constituent of the larger part of eruptive rocks, as doleryte, and amphigenyte, and many lavas; and also of some metamorphic rocks. Occurs as an ingredient in part of the Archæan rocks in North America, and was named from its first discovery in Labrador.

Andesitc. Triclinic. Angle between the cleavage planes $87^{\circ}-88^{\circ}$. Near labradorite in composition. The formula $\frac{1}{2} \mathrm{Ca}_{\frac{1}{2}} \mathrm{Na}_{2} \mathrm{AlO}_{22} \mathrm{Si}_{6}=$ Silica $59 \cdot 8$, alumina 255 , lime $7 \cdot 0$, soda $7 \cdot 7=100 \cdot 0$.
Hyalophane. Monoclinic, and hence angle between the cleavage planes $90^{\circ}$. A baryta feldspar ; the formula like that of andesite, excepting the substitution of Ba for Ca and $\mathrm{K}_{2}$ for $\mathrm{Na}_{2}$. It has been found in the Binnenthal, Switzerland, and at Jakobsberg, Sweden.
A baryta-feldspar, having the ratio of andesite, $1: 3: 8$, has been described which is triclinic, and approaches oligoclase in optical characters.

## Oligoclase.-Soda-lime Feldspar.

Triclinic. Angle between the cleavage planes $93^{\circ} 50^{\prime}$ and $86^{\circ} 10^{\prime}$. Commonly in cleavable masses. Also massive.

Color usuaily white, grayish white, grayish green, greenish, reddish. Transparent, subtranslucent. II. $=6 \cdot \%$ G. $=$ $2 \cdot 5-2 \cdot \%$.

Composition. $\frac{7}{} \mathrm{Ca}_{3} 3 \mathrm{Na}_{2} \mathrm{Al}_{14} \mathrm{Si}_{5}=$ Silica $61 \cdot 9$, alumina $24 \cdot 1$, lime $5 \cdot 2$, soda $8.8=100$. A portion of the soda is usually replaced hy potash. B.B. fuses without difficulty ; not decomposed by acids.

Obs. It occurs in granite, syenyte, and rarious metamorphic rocks, especially those containing much silica ; and in such case usually associated with orthoclase. Sunstone is in part oligoclase containing disseminated scales of hematite giving bright reflection from the interior of the stone. Occurs in Norway. Moonstone is in part a whitish opalescent variety. Oligoclase occurs at Unionville, Pa.; Haddam, Conn. ; Mineral Hill, Del. ; Chester, Mass., ctc.

## Albite.

Triclinic. Angle between the cleavage planes $93^{\circ} 36^{\prime}$, and $83^{\circ} 24^{\circ}$. Figures 1 to $6^{2}$ represent some of its forms ;


2 and 3 are twin crystals. The crystals are usually more or less thick and tabular. Also massive, with a granular or lamellar structure. Color white ; occasionally light tints of bluish white, grayish, reddish and greenish. Transparent to subtranslucent.

Composition. $\mathrm{Na}_{2} \mathrm{Al} \mathrm{O}_{16} \mathrm{Si}_{5}=$ Silica $68 \cdot 6$, alumina $19 \cdot 6$, soda $11 \cdot 8=100 \cdot 0$. B.B. fuses to a colorless or white glass, imparting an intense yellow to the flame. Not acted upon by acids.

Cleavelandite is a lamellar variety occurring in wedgeshaped masses at the Chesterfield albite vein, Mass.

Obs. Albite occurs in some granites and gneiss, and is most abundant in granite veins. Fine crystals occur at Middletown and Haddam, Conn., at Goshen, Mass., and Granville, N. Y. ; Unionville, Delaware County, Penn.

The name albite is from the Latin albus, white.

## Microcline.

A potash-feldspar, very close to the following species in angles, and also in physical characters, and identical with it in composition. But it is rery slightly trichnic, the angle between its cleavage planes varying but $16^{\prime}$ from $90^{\circ}$; and hence its cleavage surface shows usually the fine striations exhibited with rare exceptions by all the triclinic feldspars. Colors white, flesh-red, copper-green. The last is what has been called Amazon-stone ; as heat destroys the color it has been supposed to be of organic origin.

Occurs in the zircon-syenyte of Norway; also in the Urals; Greenland; Labrador; Everett, Mass.; Redding, Conn.; Delaware ; Chester County, Penn.; White Mountain Notch, green ; Pike's Peak, Amazon-stone ; Magnet Cove, Ark.

Orthoclase.-Common Feldspar.
Monoclinic ; and hence angle between the cleavage planes $90^{\circ}$. Figures 1 to 4 represent common forms, and 5 to 8 twin crystals. Usually in thick prisms, often rectangnlar, and also in modified tables. Also massive, with a granular structure, or coarse lamellar ; also finc-grained almost flintlike in compactness. Colors light; white, gray, and fleshred common ; also greenish and bluish-white and green.

Composition. $\mathrm{K}_{2} \mathrm{Al} \mathrm{O}_{16} \mathrm{Si}_{6}=$ Silica $64 \cdot 7$, alumina $18 \cdot 4$, potash $16 \cdot 9=100$. Soda sometimes replaces a portion of the potash. B.B. fuses with difficulty; not acted on by acids.

Common feldspar includes the common subtranslucent varieties; Adularia, the white or colorless subtransparent specimens, a name derived from Adula, one of the highest peaks of St. Gothard. Sanidin or glassy feldspar includes transparent vitreous crystals, found in trachytes and lavas; but some of the "glassy feldspar" belongs to the species anorthite. Loxoclase is a grayish variety with a pearly or greasy lustre that contains much soda.

Moonstone is an opalescent variety of adularia, having when polished peculiar pearly reflections. Sunstone is similar ; but contains minute scales of mica. Aventurine feld-

spar often owes its iridescence to minuto crystals of specnlar or titanic iron, or limonite. Sunstone and moonstone are mostly oligoclase, and so is a large part of aventurine feldspar.

Diff. Distinguished from the other feldspars by its rightangled cleavage and the absence of striated surfaces.

Obs. Orthoclase is one of the constituents of granite, syenyte, gneiss, and other related rocks; also of porphyry, and trachyte ; and it often occurs in these rocks in imbedded crystals. St. Lawrence County, N. Y., affords fine crystals ; also Orange County, N. I.; IFaddam and Middletown, Conn.; Acworth, N. II. ; South Rovalston and Barre, Mass., besides numerous other localities. (Green feldspar occurs at Mount Desert, Me.; an aventurine feldspar at Leiperville, Penn.; adularia at IIaddam and Norwich, Conn., and Parsonsfield, Me. A fetid feldspar (sometimes called necronite) is found at Roger's Rock, Essex County; at Thomson's quarry, near 196th Street, New York City, and 21 miles from Baltimore. Carlsbad and Elbogen in Bohemia, Baveno in Piedmont, St. Gothard, Arendal in Norway, Land's End, and the Mourne Mountains, Ireland, are some of the more interesting foreign localities.

Felsite is compact, uncleavable orthoclase, haring the texture of jasper or flint, which it much resembles. It often contains some disseminated silica. It occurs of various colors, as white, gray, brown, red, brownish red and black, and is sometimes banded. It is distinguished from flint or jasper by its fusibility.

Felsite is the material of beds or strata in some rock formations, and also of dikes or masses of eruptive rocks. It is the base of much red porphyry. The vicinity of Marblehead, Mass., is one of its localities.
The name feldspar is from the German word Fold, meaning field. It is, therefore, wrong to write it felspar.

Orthoclase is used extensively in the manufacture of porcelain. The large granite veins of Middletown and Portland, Conn., are quarried in several places for both orthoclase and quartz for this purpose; the places are often called China-stone quarries.
Faolin. This name is applied to the clay that results from the decomposition of feldspar. See Kaolinite, p. 310.

## III. SUDSIIICATES.

In the Subsilicates, as stated on page 242 , the combining or quantivalent ratio between the bases and silica is 1 to less than 1. In Chondrodite, the first of the following species, the ratio is $4: 3$; in Tourmaline, Andalusite, Cyanite, and Fibrolite, $3: 2$. Analyses of Andalusite obtain 1 of alumina, $\mathrm{AlO}_{3}$, to 1 of silica, $\mathrm{Si}_{3}$, giving the oxygen ratio for bases and silica $3: 2$. This is the comprosition also of cyanite and fibrolite ; so that the three species, andalusite, cyanite, and fibrolite are the same in constituents and atomic ratio while differing in crystalline form, exemplifying a case of trimorphism among minerals.

The ratio $3: 2$ exists also in Topaz, Eucluse and Datolite in Titanite or sphene, and in Keilhauite. In Staurolite, the ratio was formerly regarded as $2: 1$; but the most recent analyses, those of Rammelsberg, give 11: 6 , or $1_{6}^{6}: 1$. In datolite and tourmaline the basic constituents include boron ; in titanite and keilhauite, titanium ; in da-
tolite, euclase, and part of staurolite, hydrogen, that is, the hydrogen of the water found on analysis. In chondrodite, topaz, and some tourmaline, fluorine replaces part of the oxygen.

> Chondrodite.-Humite in part (Scacchi's Type II).

Monoclinic. Clearage indistinct. Usually in imbedded grains or masses. Color light yellow to brownish yellow, yellowish red, and garnet-red. Lustre vitreous, inclining a little to resinous. Streak white, or slightly yellowish or grayish. Translucent or subtranslucent. Tracture uneven. $H^{\circ}=6-$ $6 \cdot 5 . \quad(1 .=3 \cdot 1-3 \cdot 25$.

Composition. $\mathrm{Mg}_{5} \mathrm{O}_{14} \mathrm{Si}_{3}$; hut a portion of the magnesium replaced by iron, and a part of the oxygen by fluorine. A specimen from Brewster's, New York, afforded Silica $34 \cdot 1$, magnesia $53 \cdot \%$, iron protoxide $7 \cdot 3$, fluorine $4 \%$, with 0.48 of alumina $=93 \cdot \% \%$.
B.B. intusible. Decomposed by hydrochloric acid; the solution gelatinizes on evaporation.

Diff. As it cecurs only in limestone it will hardly be confounded with any speciss resembling it in color when the gangue is present. It does not fuse like tourmaline or garnet, some brownish-yellow rarieties of which it approaches in appearance. The name is from the Greek chondros, a grain.

Obs. It is abundant in the adjoining counties, Sussex, N. J., and Orange, N. Y., occurring at Sparta and Bryam, N. J., and in Warwick and other places in N. Y.; at the Tilly Foster Iron Mine, Brewster's, Putnam County, N. Y., it is very abundant. At Vesuvius it occurs in small crystals.

The species was early named Gomdrodite, from Finland specimens ; soon afterward small crystals, found in the lavas of Somma (Vesuvins), were named Humite, and both were referred to the same species. It has recently been ascertained that under this species, two species of different angles and form, but related composition and physical character, are included. For these species the names Humite and Clinohumite have been adopted.

Humite is orthorhombic, and embraces part of the Humite crystals of Vesuvins (Scacchi's Type I.), and some large coarse chondrodite-like crystals found at Brewster's, N. Y.

Clinolumite is monoclinic, and includes Scacchi's Type III.
of Humite from Vesuvius, and fine chondrodite-like crystals from Brewster's.

## Tourmaline.

Rhombohedral. Usual in prisms of $3,6,9$, or 12 sides, terminating in a low 3 -sided pyramid. The sides of the prisms are often rounded and striated. Other forms are shown in the figures. The common pyramid is the rhombo-

hedren - $\frac{1}{8}$ in the figures, the angle of which is $133^{\circ} 8^{\prime}$. The crystals often have unlike secondary planes at the two extremitics, as shown in figure 3. Occurs also compact massive, and coarse columnar, the columns sometimes radiating or divergent from a centre.

Color black, blue-black, and dark brown, common ; also bright and pale red, grass-green, cinnamon-brown, yellow, gray, and white. Sometimes red within and green externally, or one color at one extremity and mother at the other. Transparent; usually translicent to nearly opaque. Dichroic. Lustre vitreons, inclining to resinous on a surface of fracture. Streak uncolored. Brittle; the crystals often fractured across and breaking very easily. II. $=\boldsymbol{7} \cdot 0-7 \cdot 5$. ( A . $=3-3 \cdot 3$.

Composition. $\left(\mathrm{R}_{3}, \mathrm{~B}_{2}, \mathrm{R},\right) \mathrm{O}_{5}$, $\mathrm{Si}_{2}$, in which R includes, in different varieties, $\mathrm{Fe}, \mathrm{Mg}, \mathrm{Na}_{2}$, with often traces also of Ca , $\mathrm{Mn}, \mathrm{K}_{v}, \mathrm{Li}_{2}$; If inclades aluminum, with some boron in the trioxide state replacing Al ; and a little of the oxygen is sometimes replaced by fluorine.

A black tourmaline from Haddam afforded on analysis, Silica $37 \cdot 50$, boron trioxide (by loss) $9 \cdot 02$, alumina $30 \cdot 87$, iron protoxide $8 \cdot 54$, magnesia $8 \cdot 60$, lime $1 \cdot 33$, soda $1 \cdot 60$, potash $0 . \%$, water $1 \cdot 81=100$. A red tourmaline from Paris, Maine, afforded Fluorine $1 \cdot 19$, silica $41 \cdot 16$, boron trioxide (by loss) $8 \cdot 93$, slumina $41 \cdot 83$, manganese protoxide 0.95 , magnesia $0 \cdot 61$, soda $1 \cdot 37$, potash $2 \cdot 1 \%$, lithia $0 \cdot 41$, water $2 \cdot 57$ $=100$.

Tourmenine varies much in color owing to its variations in
composition ; the dark contain much iron and the light colors but little. Some of the varieties have received special names. Rubellite is red tourmaline; and Indicolite, blue and bluish-black. Schorl formerly included the common black tourmaline, but the name is not now used.

The presence of boron trioxide is the most remarkable point in the constitution of this mineral. The colorless, red, and pale-greenish kinds usually contain lithia. B.B. the darker varietics fuse with ease, and the lighter with difficulty. On mixing the powdered mineral with potassium bisulphate and fluor spar, and heating B.B., gives a green flame owing to the boron.

Diff. The black and the dark varieties generally, are readily distinguished by the form and lustre and absence of distinct cleavage, together with their difficult fusibility. The black when fractured often appear a little like a black resin. The brown variety resembles garnet or idocrase, but is more infusible. The red, green, and yellow varieties are distinguished from any species they resemble by the crystalline form, the prisms of tourmaline always having $3,6,9$, or 12 prismatie sides (or some multiple of 3 ). The electric properties of the crystals, when heatod, is another romarkable character of this mineral. The test for boron is always good.

Obs. Tourmalines are common in granite, gneiss, mica schist, chlorite schist, steatite, and granular limestone. They usually occur penetrating the rock. The black crystals are often highly polished and at times a foot in length, when perhaps of no larger dimensions than a pipe-stem, or even more slender. This mineral has also been observed in sandstones near basaltic or trap dikes.

Red and green tourmalines, over an inch in diameter and transparent, have been obtained at Paris and Hebron, Me., besides pink and blue crystals. These keveral varieties occur also, of less beauty, at Chesterfield and Goshen, Mass. Good black tourmalines are found at Norwich, New Braintree, and Carlisle, Mass. ; Alsted, Acworth, and Saddleback Mountain. N. II. ; Maddam and Monroe, Conn. ; Saratoga and Edenville, N. Y. ; Franklin and Newton, N. J.; near Unionville, Chester, and Middletown, Penn. ; transparent brown at Hunterstown, Canada East; amber-colored at Fitzroy; black at Bathurst, and Elmsley, Canada West; fine greenish yellow at G. Calumet I.

Dark brown tourmalines are obtained at Orford, N. H.; in thin black crystals in mica at Grafton, N. H. ; Monroe, Ct. ; Gouverneur and Amity, N. Y. ; Franklin and Newton, N. J. A fine cinnamon-brown varicty occurs at Kingsbridge and Amity, Orange Go., N. Y. and also south in New Jersey. A gray or bluish-gray and green variety occurs near Edenville.

The word tourmaline is a corruption of the name used in Ceylon, whence it was first brought to Europe. Lyncurium is supposed to be the ancient name for cominon tourmaline; and the red variety was probably called hyacinth.

The red tourmalines, when transparent and free from cracks, such as have been obtained at laris, Me., are of great value and afford gems of remarkable beauty. They have all the richness of color and lustre belonging to the ruby, though measuring an inch across. The ycllow tourmaline, from Ceylon is bat little inferior to the real topaz, and is often sold for that gem. The green specimens, when clear and fine, are also valuable for crems. Plates from pellucid crystals cut in the direction of a verlical plane are much used for polariscopes.
Gehlenitc. Tetragonal, like the scapolites, and grayish green in color. G. $=2 \cdot 4-3 \cdot 0 \tilde{\pi}$. Formula $\mathrm{Ca}_{3} \mathrm{AlO}_{n} \mathrm{Si}_{2}$ with some of the Al replaced by Fe, and some of the Ca by Fe and Mg. From Mount Monzoni in the Fassa Valley.

## Andalusite.

Trimetric. In rhombic prisms, which are nearly square ; $I \wedge I=90^{\circ} 48^{\prime}$. Cleavage lateral; sometimes distinct. Also massive and indistinctly coarse columnar, but never fine fibrous.

Colors gray and flesh-red. Iustre vitreous, or inclining to pearly, Trinslucent to opaque. Tough. II. $=7.5$. G. $=$ $3 \cdot 1-3 \cdot 3$.


Composition. $\mathrm{AlO} \mathrm{O}_{\mathrm{B}} \mathrm{Si}=$ Silica $36 \cdot 9$, alumına $63 \cdot 1=100$. B. B. infusible. Ignited after being moistened with cobalt nitrate assumes a blue color. Insoluble in acids.

Chiastolite and macle are names given to crystals of amlalusite which show a tessellated or cruciform structure when broken across and polished. The above figures represent sections of erystals from Lancaster, Mass. The structure is owing to carbonaceous impurities distributed in the crystallizing process in a regular mamer along the sides, edges and diagonals of the crystal. Their hardness is sometimes as low as 3.

Diff. Distinguished from pyroxene, scapolite, epodumene, and feldspar, by its infusibility, hardness, and form.

Obs. Most abundant in clay slate and mica slate, but occurring also in gneiss. Found in the Tyrol, Saxony, Bavaria, ctc.; also in Westford, Mass.; Litchfield and Washington, Ct. ; Bangor, Me. ; Leiperville, Marple, and Springtield, Penn. ; and chiastolite at Sterling and Lancaster, Mass., and near Bellows Falls, Vermont. This species was first found at Audalusia in Spain.

## Fibrolite.--Sillimanito. Bucholzite.

Orthorhombic. In long, slender rhombic prisms, often much flattened, penetrating the gangue. $I \wedge I=96^{\circ}-98^{\circ}$. A brilliant and casy clearage, parallel to the longer diagonal. Also in masses, consisting of aggregated crystals or fibres. Color hair-brown or grayish brown. Lustre vitreous, inclining to pearly. Translucent crystals break easily. II. $=6-\% . \quad$ G. $=3 \div-3 \cdot 3$.

Composition. $\mathrm{AlO}_{5}$ Si, as for andalusite, $=$ Silica $36 \cdot 9$, ahumina $63 \cdot 1=100$. Moistened with cobalt nitrate and ignited assumes a bute color. Infusible alone and with borax.

Diff. Distinguished from tremolite and the varieties gencrally of hornblende by its brilliant diagonal cleavage, and its infusibility ; frum kyanite and andalusite by its brilliant cleavage, its fibrons structure, and its rhombic crystalline form.

Obs. Found in gneiss, mica schist, and related metamorphic rocks. Occurs in the Tyrol, at Bodenmais in Bavaria; at the White Mountain Notch in N. H.; at Chester and near Norwich, Conn. : Yorktown, N. Y. ; Chester, Birmingham, Concord, Darby, Penn.; in North Carolina; and elsewhere. Fibrolite was much used for stone implements in Western Europe in the "Stone age; " the locality whence the material was derived is not known.

## Cyanite.-Kyanite. Disthene.

Triclinic. Usually in long thin-bladed crystals aggregated together, or penetrating the ganguc. Sometimes in short and stout crystals. Lateral cleavage distinct. Sometimes fine fibrous.

Color usually light bluc, sometimes haring a bluc centre with a white margin; sometimes white, gray, green, or even black. Lustre of flat face a little pearly. II. $=\tilde{0}-\% \cdot 5$, greatest at the ends of the prisms, and least on the flat face of the prism. G. $=3 \cdot 45-3 \cdot \%$.

Composition. $\mathrm{AlO}_{5} \mathrm{Si}$, as for andalusito, =Silica $30 \cdot 9$, alumina $63 \cdot 1=100$. Blowpipe characters like those of andalusite.

Diff. Distinguished by its infusibility from varieties of the hornblende family. The short crystals hare some resemblance to staurolite, but their sides and terminations are usually irregular ; they differ also in their cleavage and lustre. The thin-bladed habit of cyanite is very characteristic.

Obs. Found in gneiss and mica schist, and often accompanied by garnet and staurolite.

Occurs in long-bladed crystallizations at Chesterfield and Worthington, Mass.; at Litchficld and Washington, Conn.: near Philadelphia; near Wilmington, Delaware; and in Buckingham and Spotsylvania counties, Va. Short crystals (sometimes called improperly filrolite) occur in gnciss at Bellows Falls, Vt., and at Westfield and Lancaster, Mass.

In Europe, at St. Cothard in Switzerland, at Creiner and Pfitsch in the Tyrol, in Styria, Carinthia, and Bohemia. Villa Rica in South America affords fine specimens.

The name cyanite is from the Greek kutnos, a dark-blue substance. It is also called disthene, in allusion to the unequal hardness in different directions, and when white, rhextiate.

Kyanite is sometimes used as a gem, and has some resemblance to sapphire.

## Topaz.

Trimetric. $I \wedge I=124^{\circ} 17^{\prime}$. Rhombic prisms, nsually differently modified at the two extremities. $\quad I \wedge I=124^{\circ} 1^{7^{\prime}}$. Cleavage perfect parallel to the base.

Color pale yellow ; sometimes white, greenish, bluish, or
reddish. Streak white. Lustro vitreons. Transparent to subtranslucent. Pyro-electric. $\mathrm{I} .=8$. $\mathrm{G}=3 \cdot 4-3 \cdot 65$.

Composition. $\mathrm{AlO}_{5}$ Si, with a part of the oxygen replaced by fluorine $=$ Silica $16 \cdot 2$, silicon fluorid $28 \cdot 1$, alumina $55 \cdot \%$

$=100$. An analysis of one specimen afforded, Silica 34.24, alumina $57 \cdot 45$, fluorine $14 \cdot 99$. B.B. infusible. Some kinds become yellow or of a pink tint when heated. Moistened with colnalt nitrate and ignited assumes a fine blue color. Insoluble in acids.
l)iff. Topaz is readily distinguished from tourmaline and other minerals it resembles by its brilliant and easy basal clearage.

Obs. Pycnite is a variety presenting a thin columnar structure and forming masses imbedded in quartz. The Physulite or Pyrophysalite of Hisinger is a coarse, nearly opaque rariety, found in yellowish-white crystals of considerable dimensions. This varicty intumesces when heated, and hence its name from phusao, to blow, and pur, fire.

Topaz is confined to metamorphic rocks or to reins intersecting them, and is often associated with tourmaline, beryl, and occasionally with apatite, fluorite, and tin ore.

Fine topazes are brought from the Uralian and Altai mountains, Siberia, and from Kamschatka, where they occur of green and blue colors. In Brazil they are found of a deep yellow color, either in veins or nests in lithomarge, or in loose crystals or pebbles. Magnificent crystals of a sky-blue color have been obtained in the district of Cairngorm, in Aberdeenshire. The tin mines of Schlackenwald, Zimmwald, and Ehrenfriedersdorf in Bohemia, St. Michael's Mount in Cornwall, etc., afford smaller crystals. The physalite variety occurs in crystals of immense size at Finbo, Sweden, in a granite quarry, and at Broddbo. A well-defined crystal from this locality, in the possession of the College of Mines of Stockholm, weighs eighty pounds. Altenberg in

Saxony, is the principal locality of pyenite. It is there associated with quartz and mica.
'Trumbull, Comn,, is a prominent locality of this species in the United States. It seldom affords fine tramsparent crystals, except of a small size ; these are usually white, occasionally with a tinge of green or yellow. The large coarse crystals sometines attain a diameter of several inches (rarely six or seven), but they are deficient in lustre, usually of a dull yellow color, thongh occasionally white, and often are nearly opaque. It is found also at Crowder's Mountain in N. C. ; in Utah, in Thomas's Mountains, and in gold washings in Oregon.

The aucient topuzion was found on an island in the Red Sea, which was often surrounded with fog, and therefore difficult to find. It was hence named from toppozo, to seek. This name, like most of the mineralogical terms of the ancients, was applied to several distinct species. Pliny describes a statue of Arsinoe, the wife of Ptolemy Philadelphus, four cubits high, which was made of topazion, or topaz, but evidently not the topaz of the present day, nor chrysolite, which has been supposed to be the ancient topaz. It has been conjectured that it was a jasper or agate; others have supposed it to be prase or chrysoprase.

Topaz is employed in jewelry, and for this parpose its color is often altered ly heat. The variety from Brazil assumes a pink or red hue, so nearly resembling the Balas ruby, that it cau only be distinguished by the facility with which it becomes electric by friction. Beautiful erystals for the lapidary are brought from Minas Novas, in Brazil. When cut with facets and set in rings, they are readily mistaken, if viewed by daylight, for diamonds. From their peculiar limpidity, topaz pebbles are sometimes denominated gouttes d'cuu.
The perfect cleavage of topaz makes it a poor substitute for emery.

## Euclase.

Monoclinic. In oblique rhombic prisms, with cleavage lighly perfect parallel to the clinodiagonal section, affording smouth polished faces.
Color pale green to white or colorless, pale blue. Lustre vitreous; transparent. Brittle. $\mathrm{H} .=7 \%$. G. $=3 \cdot 1$. Pyroelectric.

Composition. $\mathrm{H}_{2} \mathrm{Be}_{2} \mathrm{Al}^{0} \mathrm{O}_{10} \mathrm{Si}_{2}=$ Silica $41 \cdot 20$, alumina $35 \cdot 2 尺$, glucina $17 \cdot 39$, water $6 \cdot 19=100$. B. B. fuses with much difficulty to a white cnamel ; not acted on by acids.

Diff. The clearage of this glassy mineral is, like that of topaz, very perfect, but is not basal. The cleavage distinguishes it from tourmaline and beryl.

Obs. Occurs in the Ural, and with topaz in Brazil.
The crystals of this mineral are elegant gems of themselves, but they are seldom cut for jewelry on account of thioir brittleness.

> Datolite.-Datholite. Humboldtite.

Monoclinic. Crystals without distinct cleavage ; small and glassy. Also botryoidal, with a columnar structure, and then called botryolite. Color white, occasionally grayish, greenish, yellowish, or reddish. Translucent. $\mathrm{IL}=5-5 \%$. $\mathrm{G} .=2 \cdot 8-3$.

Composition. $\mathrm{H}_{2} \mathrm{Ca}_{2} \mathrm{~B}_{2} \mathrm{O}_{\mathrm{r} 0} \mathrm{Si}_{2}$ $=$ Silica $3 \% \cdot 5$, boron trioxide $21 \cdot 9$, lime $35 \cdot 0$, water $5 \cdot 6=$ 100. Butryolite contains twice
 the proportion of water. B.B. becomes opaque, intumesces and melts casily to a glassy globule coloring the flame green. Decomposed by hydrochloric acid ; the solution gelatinizes on evaporation.
Diff. Its glassy complex crystallizations, without clearace, are unlike any other mincral that gelatinizes with acid. It is distinguished from minerals that it resembles also by tingeing the blowpipe-flame green.

Obs. Occurs in cavities in trap rocks and gnciss. Found in Scotland; at Andreasburg ; at Baveno; Troggiana; also Bergen Hill, in N. J.; in Connecticut, at Roaring Brook, 14 niles from New Haven; and near Hartford, Berlin, Middlefield Falls, Conn.; also in great abundance at Eagle Harbor in the copper region, Lake Superior, and on Isle Royale; also noar santa Clara, Cal.

Homilitc. A black silicate of iron and calcium, resembling gadolinite, but affording from 15 to 18 per cent. of boracic acid with $8: 3$ of silica; formula $\mathrm{R}_{2} \mathrm{~B}_{2} \mathrm{O}_{10} \mathrm{Si}_{2}$. From Brevig, Norway.

Titanite.-Sphene.
Monoclinic. In very oblique rhombic prisms ; the lateral faces making angles often of ${ }^{\prime} 6^{\circ} 7^{\prime}, 113^{\circ} 31^{\prime}(I \wedge I), 136^{\circ} 12^{\prime}$

3.

( $2 \wedge 2$ ), or $133^{\circ} 52^{\prime}$. The crystals are usually thin with sharp edges. Clearage in one direction sometimes perfect. Occasionally massive.

Color grayish-brown, ash-gray, brown to black; sometimes pale yellow to green; strak uncolored. Iustre adamantine to resinous. Transparent to opaque. H. $=5$ $5 \cdot 5 . \quad \mathrm{G} .=3 \cdot 2-3 \cdot 6$.

Composition. $\mathrm{CaTiO}_{5} \mathrm{Si}=$ Silica $30 \cdot 6$, titanium dioxide $40 \cdot 82$, lime $28: 57=100$; in dark brown and black crystals, some iron replaces part of the calcium. B.B. fuses with intumesence. Imperfectly decomposed by hydrochloric acid.

The dark varieties of this species were formerly called titanite, and the lighter sphene. The name sphene alludes to the wedge-shaped crystals, and is from the Greek sphen, wedge. Greenovite is a variety colored rose-red by manganese.

Diff. The thin wedre-like form of the crystals, in general, readily distinguish this species; but some crystals are very complex.

Obs. Sphene occurs mostly in disseminated crystals in granite, gneiss, mica slate, syenyte, or granular limestone. It is usually associated with pyroxene and scapolite, and often with graphite. It has been found in volcanic rocks. The crystals are commonly $\frac{1}{4}$ to $\frac{1}{2}$ an inch long ; but are sometimes 2 or more inches in length.

Forcign localities are Arendal in Norway ; at St. Gothard and Mont Blanc ; in Argyleshire and Galloway in Great Britain. Occurs in Canada, at Grenville and elsewhere; New York, at Roger's Rock, on Lake Ceorge ; with graphite
and pyroxene, at Gouverneur, near Natural Bridge in Lewis County (the variety called Lederite); in Orange County in Monroe, Edenville, Warwick, and Amity ; near Peekskill in Westchester County, and near West Farms ; in Massachusetts, at Lec, Bolton, and Pelham ; in Connecticut, at Trumbull; in Maine, at Sanford, and 'Thomaston ; in New Jersey, at Franklin; in Pennsylyania, near Attleboro', Bucks County; in Delaware, at Dixon's quarry, 7 miles from Wilmington ; in Maryland, 25 miles from Baltimore, on the Gunpowder.
Guarinite. Like sphene in composition, but trimetric.
Keilhauite, or Yttro-titanitc. Related to sphene. Brownish-black, with a grayish-brown powder. G. $=3 \cdot 69 . \mathrm{H} .=6 \cdot 5$. Fuses easily. Affords Silica $30 \cdot 0$, titanic acid 290 , ytria $9 \cdot 6$, lime $18 \cdot 9$, iron sesquioxide $6 \cdot 4$, alumina 6.1 . From Arendal, Norway.

Tscheffkinite. Near Keilhauite. From the Ilmen Mountains.

## Staurolite.-Staurotide.

Trimetric. $I \wedge I=129^{\circ} \stackrel{2}{2} 0^{\prime}$. Clearage imperfect. Usual-


Color dark brown or black. Lustre vitreous, inclining to resinous ; sometimes bright, but often dull. Translucent to opaque. II. $=7-7 \cdot 5$. G. $=3 \cdot 4-3 \cdot 8$.

Composition. $\mathrm{II}_{2} \mathrm{R}_{3} \mathrm{Al}_{6} \mathrm{O}_{34} \mathrm{Si}_{6}=$ Silica $30 \cdot 37$, alumina 51.92 . iron protoxide $13 \cdot 66$, magnesia $2 \cdot 53$, water $1 \cdot 52=100$. B.B. infusible. Insoluble in acids.

Diff. Distinguished from tourmaline and garnet by its infusibility and form.

Obs. Found in mica slate and gneiss, in imbedded crystals.

Occurs very abondant through the mica schist of New England : Franconia, Vt.; Windham, Me. ; Lisbom, N. II.; Chesterfield, Mass. ; Bolton and Tolland, Ct. ; also on tho Wichichon, eight miles from Philadelphia; at Canton, and in Fannin County, Georgia. Mt. Campione in Switzerland, and the Greiner Mountain, Tyrol, are noted foreign localities.

The name staurolite is from the Greck stauros, a cross.
Schorlomite. Black, and often irised tarnished. Streak grayish-black. $\mathrm{H} .=7-7 \%$. G. $=3.80$. Fuses readily on charcoal. Easily decomposed by the acids, and gelatinizes. Contains much titanium, with iron. lime, and silica. From Magnet Cove, Arkansas, and Kaiserstuhlgebirge, Breisgau.

## B. HYDROUS SILICATES.

Tho three sections under which the Hydrous Silicates are arranged are the following :
I. General Section. Under this section there are included: (1) Bisilicates-Pectolite, Laumontite, Apophylite, etc. ; (2) Unisilicates-Prehnite, Calamine, ctc. ; and (3) Subsilicate:-as Allophane, and some related species.
II. Zeolite Section. The minerals included are feld-spar-like in constituents, and apparently so in quantivalent (or oxygen) ratio ; the basic elements being, as in the feldspars, (1) aluminum, and (i) the metals of the alkalis $K$, Na , and of the alkaline earths $\mathrm{Ca}, \mathrm{Ba}$, with also Sr , to the almost total exclusion of magnesium and iron.
III. Margaropiyllite Section. This section embraces species having a micaceous or thin-foliated structure when crystallized, with the surface of the folia pearly, and the plane angle of the base of the prism $120^{\circ}$. Whether crystallized or massive the feel is greasy, at least when pulverized. It comprises (1) Bisilicates: including Tale and Pyrophyllite, which are atomically and physically similar species, although the former is a magnesium silicate, and the latter an aluminum silicate ; ( ${ }^{2}$ ) Non-alkaline Unisilicates, including Kaolinite and Serpentine, which have a similar difference in constituents to the preceding with the same likeness in composition, and also some related species ; (3) Alkaline Unisilicates: as, Pinite and the IIydrous Micas, which are species containing potassium or sodium as an essential constituent ; (4) the Chlorite Group, the species of which are mostly Subsilicates.

## I. GENERAL SECTION. Pectolite.

Monoclinic, isomorphous with wollastonite. Usually in aggregations of acicular crystals, or fibrous-massive, radiate, stellate. Color white, or grayish. Translucent to opaque. Tough. H. $=5 . \quad$ G. $=2 \cdot 68-2 \cdot 8$.

Composition. $\mathrm{R} \mathrm{O}_{3} \mathrm{Si}$, in which $\mathrm{R}=\frac{1}{6} \mathrm{H}_{2} \frac{1}{6} \mathrm{Na}_{2} \frac{4}{6} \mathrm{Ca}$, = Silica $54 \cdot 2$, lime $33 \cdot 8$, soda $9 \cdot 3$, water $2 \cdot \%=100$. In the closed tube yields water. B. B. easily fusible. Decomposed by hydrochloric acid, and the solution gelatinizes somewhat when eraporated.

Diff. Its fibrous forms and its blowpipe reactions are distinctive.

Obs. Occurs mostly in cavities or seams in trap or hasic ermptive rocks, and occasionally in other rocks. Fonnd at Ratho Quarry, noar Edinburgh, Scotland; at Kilsyth ; Isle of skye; in the Tyrol; in fine specimens at Bergen Hill, N. J.; a compact rariety at Isle Royale, Lake Superior.

Okcnite and Gyrolite are related liydrous calcium silicates. Okenite is from the Faroe Islands, Iceland, and Greenland, and gyrolite from the Isle of Skye, and from Nova Scotia 25 miles southwest of Cape Blomidon.

Cymatolite. White, curved-fibrous (to which the name from the Greek kima, noave, alludes), vitreo-pearly, with ( $\mathbf{G}=2.74$. Analysis afforded Silica $61 \cdot 21$, alumina 28.01 , potassium 4.54 , water 383 , with about half a per cent. each of lime, soda, and lithia, making it a hydrous bisilicate, if half the water be made basic. Derived from the alteration of spodumene. Occurs at Goshen and Norwich, Mass., and Redding, Conn. At the latter place crystals of spodumene of great size are converted into it.

## Laumontite.

Monoclinic, with the angles nearly of pyroxene ; $I \wedge I=$ $86^{\circ} 16^{\prime}$. Cleavare parallel to the elinodiagonal section and to $I$ perfect. Also massive, with a radiatiug or divergent structure.

Color white, passing into yellow or gray, sometimes red. Lustre vitreons, inclining to pearly on the cleavage face. Transparent to translucent. $\quad \mathrm{H} .=3 \cdot 5-4 . \quad \mathrm{G} .=2 \cdot 25-2 \cdot 36$. Becomes opaque on exposure through luss of water, and readily crumbles.

Composition. $\mathrm{CaAlO} \mathrm{O}_{12} \mathrm{Si}_{4}+4 \mathrm{aq}=$ Silica $50 \cdot 0$, alumina $21 \cdot 8$, lime $11 \cdot 9$, water $16 \cdot 3=100$. B.B. swells up and fuses
easily to a white enamel. Decomposed by hydrochloric acid, and the solution gelatinizes on evaporation.

Diff. The alteration this species undergoes on exposure to the air at once distinguishes it. This result may be prevented with cabinet specimens, by dipping them into a solution of gum arabic.

Obs. Found in the veins and cavities of trap rocks and also in gneiss, porphyry. Occurs at the Faroc Islands; Kilpatrick Hills, near Glasgow ; Disko, Greenland : St. Gothurd, Switzerland ; Peter's Point, Nova Scotia; Phippsburg, Me.; Charlestown syenite quarrics, Mass. ; Bergen Hill, N. J.; the Copper region, Lake Superior, and Isle Royale.

## Apophyllite.

Dimetric. In square octahedrons, prisms, and tables. Cleavage parallel with the base highly perfect. Massive

$$
1 .
$$


4.

and foliated. Color white or grayish shade of green, yellow, or red. Lustris other faces vitreous. Transparent ${ }^{\circ}$ G. $=2 \cdot 3-2 \cdot 4$.

Composition. A silicate of calc bined, with potassium fluoride got $\left(\frac{1}{2} \mathrm{H}_{2} \frac{1}{2} \mathrm{Ci}\right) \mathrm{O}_{3} \mathrm{Si}+\frac{1}{8} \mathrm{KF}+\frac{1}{2} \mathrm{aq}=\mathrm{S}: \frac{{ }_{2}^{2}}{2} \quad a K \cdot 97$, lime $24 \cdot r 2$, potash 5.20, water $15 \cdot 90$, fluorine $2 \cdot 10=100 \cdot 89$. B. B. exfoliates, colors the flame violet (owing to the potash), and fuses very casily to a white cnamel. In the closed tube yields water which has an acid reaction. Decomposed by hydrochloric acid with the separation of slimy silicia.

Diff. The pearly basal clearare and the forms of its glassy crystals at once distinguish it from the preceding species. The prisms are sometimes almost cubes, with the angles cut off by the planes of the pyramid ; but the difference in the lustre of the prismatic and basal faces shows that it is dimetric.

The name alludes to its exfoliation before the blowpipe.
Obs. Found in amygdaloidal trap and basalt.
Occurs in fine crystallizations at Peter's Point and Partridge Island, Nova Seotia, at Jergen Mill, N. J., the Cliff Mine, Lake Superior region.

Catapleite. A lyydrous zirconium and sodium silicate, from Norway.

Dioptase and Chrysocolla. Hydrous copper silicates. See p. 141.
Picrosmine, Pyrallolite, Picronhyll, Traversellite, Pitkarandite, StraKonitzite, Monradite, are names of varieties of pyroxene in differeni stages of alteration. Xylotine is probably altered asbestus.

## Prehnite.

Trimetric. I $I \wedge I=99^{\circ} 56^{\prime}$. Clearage basal. Sometimes in six-sided juisms, romuded so as to be barrel-shaped, and compord of a series of unted phates; also in thin rhombie or hexagonal plates. Usually reniform and botryoidal, with a erystalline surface ; texture compact.

Color light green to colorless. Lustre vitreons, exeept the face (), which is somewhat pearly. Subtransparent to translucent. $\quad \mathrm{H}=(6-6.5 . \quad(\mathrm{E} .=2 \cdot 8 \sim 2 \cdot 90$.

Composition. $\mathrm{H}_{2} \mathrm{Ca}_{2} \mathrm{Al} \mathrm{O}_{12} \mathrm{Si}_{9}=$ Silici $43 \cdot 6$, alumina $24 \cdot 9$, lime $2 \% \cdot 1$, water $4 \cdot 4=100$. B.B. fuses very easily to an ch-amel-like glass. Decomposed by hydrochlorie acid, leaving a residue of silica in light flakes, but the solution does not gelatinize. Yields a little water when heated in a closed tube.

Diff. Distinguished from beryl, green quartz, and chalcedony by fusing before the blowpipe, and from the zeolites by its superior hardness.

Obs. Found in the carities of trap, gneiss, and granite.
Occurs in the trap rocks of the Connecticut Valley, and at Paterson and Bergen Hill, N. J. ; in gneiss at l Bellows Falls, Vt. ; in syenyte at Charlestown, Mass.; and very abundant, forming large veins, in the Cupper region of Lako Superior, three miles south of Cat Harbor, and elsewhere.

The Fassa Valley in the Tyrol, St. Christophe in Dau-
phiny, and the Salisbury Crag, near Edinburgh, are some of the foreign localities.

Prehnite receives a handsome polish and is sometimes used for inlaid work. In China it is polished for ornaments, and large slabs have been cut from masses brought from there.

Chlorastrolite and Zonochloritc, from the Lake Superior region, are impure prehnite.

Chalcomoryhite. $\Lambda$ hydrous calcium silieate, from calcite in cavities of lava, containing but 25.4 per cent. of silica.

Gismondite (Zcagonite). A hydrous lime-aluminum silicate, occurring in trimetric crystals resembling square octahedrons; found in lava at Capo di llove, near Rome.

Edingtonite. A hydrous barium-aluminum silicate. Occurring in crystals and massive. From the Kilpatrick Hills, with harmotome.

Carpholite. A manganese-aluminum silicate, occurring in silky, yellow, radiatcd tufts. From the tin mines of Schlackenwald.

Pyrosmalite. A manganese-iron silicato and chloride, from Sweden.
Callemine. A hydrous zinc unisilicate. See p. $15 \%$.
Fillarsite. Probably altered chrysolite.
Ccrite, Iritomite, Erdmannite, are cerium and lanthanum silicates.
Thorite (Orangite) and E'ucrusitc, are thorium silicates; the latter hydrous.

## Allophane.

In amorphous incrustations, with a smooth small-mammillary surface, and often hyalite-like, and sometimes pulverulent. Color pale bluish-white to greenish-white, and deep green ; also brown, yellow, colorless. Translucent. $11 .=3 . \quad \mathrm{G} .=1 \cdot 85-1 \cdot 89$.

Composition. Mostly $A 1 O_{5} \mathrm{Si}+6$ (or 5 ) ar. Silica $23 . \%$, alumina $40 \cdot 62$, water $35 \cdot 63=100$. In the closed tube'velds much water. B.B. infusible, but crumbles. A blue color with cobalt solution, and a jelly with hydrochloric acid.

Occurs in Susony; at the Chessy Copper Mine near Lyons; at a copper mine in Bohemia; with limonite in Moraria ; in Old Chalk Pits near Woolwich, England ; with gibbsite in limonite beds in lichmond, Mass.; at the copper mine of Bristol, Conn.; at Morgantown, I'ir. ; copper mines of Polk County, Tenn.

Collyrite. A hydrous aluminum silicate containing only 14 to 15 per cent. of silica, and 35 to 40 of water ; and Sehrïtterite is another with 11 to 12 per cent. of silica. The latter has been reported as occurring, as a gum-like incrustation, at the falls of Little River, on Sand Mountain, Cherokee County, Alabama, Scarbroitc is a related mineral of doultful nature.

## II. ZEOLITE SECTION.

The species of the Zeolite Section have been described as having some relation to the feldspars in constitution. In the feldspars, as explained on page 273, the following ratios, for the protoxides, alumina, and silica which analyses afford, occur: 1:3:4, 1:3:6, 1:3:8, 1:3:9, 1:3:10, 1:3:12. So, among the zeolites, if the water be left out of consideration, these are the ratios: 1:3:4 (in Thomsonite), 1:3:6 (Natrolite, Scolecite, etc.), 1:3:8 (Analcite, Chabazite, etc.), 1:3:10 (1Iarmotome), 1:3:12 (Stillite, Heulandite, etc.). This fact, added to the absence or nearly total absence of magnesium and iron, and presence instead of $\mathrm{Na}_{2}$, $\mathrm{K}_{2}, \mathrm{Ca}, \mathrm{Ba}$, make out a distinct relation to the feldspars, whatever may le the part which the water sustains in the compounds. lesides barium, strontium is sometimes present, an clement not yet known to characterize a species of feldspar.
These minerals were called zeolites because they generally fuse casily with intumescence before the blowpipe, the term being derived from the Greek zen, to luil. Among those described beyond, Ieulandite and Stillite, have a strong pearly clearage, and the latter is often in pearly radiations; Natrolite, Scolecite, are fibrous and radiated, or in very slender prisms ; Thomsonite oceurs cither radiated, or compact, or in short crystals; while Itarmotome, Analcite, and Chabazite, and the related Cmelinite, occur only in short or stout glassy crystals, those of chabazite looking sometimes like cubes.

The zeolites are sometimes called trap minerals, because they are often found in the cavities or fissures of amygdaloidal trap as well as related basic eruptive rocks. Yet they occur also occasionally in fissures or cavities in gneiss, granite, and other metamorphic rocks. They are not the original minerals of any of these rocks; but the results of alteration of portions of them near the little cavities or fis-
sures in which the minerals ocenr ; and part were made while the rock was still hot, and as cooling went forward. Besides true zeolites, such cavities often contain also Laumontite (p. 293), noted for its tendency to crumble on exposure; Pectolite and Okenite (p. 293), which are fibrous like Natrolite and Scolecite ; Apophyllite (1. 294), having one pearly cleavage like heulandite and stilbite; Prehnite (1. 295), usually apple-green ; Datolite (p. 289), in stoutish glassy complex crystals, or in smooth botryoidal forms ; Aragonito (p. 218), sometimes radiated fibrous, and Calcite ( $p$. 215) with its three directions of like casy clearage, both effervescing with hydrochloric acid; Siderite (p. 185), in spheroidal or other forms ; Chlorite (p. 316), of dark olive-green color ; and Quartz, cither in crystals, or as chalcedony, agate, or carnelian, and in cither caso easily distinguished by the hardness, absence of clearage, and infusibility. Of all these species Calcite and Quartz are the most common. Of rarer occurrenco than the above, there are Orthoclase, $\Lambda$ sphaltic coal, Copper, etc.

All the zeolites yield water in the closed tube, and many of them gelatinize with hydrochloric acid.

## Thomsonite.

Trimetric. In right rectangular prisms. Tisually in masses having a radiated structure within, and consting of long fibres, or acicular crystals; also amorphous.

Color snow-white ; impure varieties brown. Lustre ritreous, inclining to pearly. Transparent to translucent. H. $=5-5$. Brittle. G. $=2 \cdot 3-2 \cdot 4$.

Composition. ( $\mathrm{Ca}, \mathrm{Na}_{2}$ ) $\mathrm{Al} \mathrm{O}_{8} \mathrm{Si}_{2}+21 \mathrm{aq}=$ Silica $38 \cdot 09$, alumina $31 \cdot 62$, lime $12 \cdot 60$, soda $4 \cdot 62$, water $13 \cdot 40=100 \cdot 20$.
B.B. fuses very casily to a white enamel. Decomposed by hydrochloric acid; the solution gelatinizes when evaporated.

Diff. Distinguished from natrolite by its fusion to an opaque and not to a glassy globule.

Obs. Occurs in amygdaloid, near Kilpatrick, Scotland; in lavas at Vesuvius, Comptonite; in clinkstone in Bohemia; the Tyrol, etc. ; at Peter's Point, Nova Scotia, in trap; a massive variety, called Ozarkitc, at Magnct Cove, Ark.

The species was named after Dr. Thomas Thomson, of Glasgow.

## Natrolite.

Trimetric. In slender prisms, terminated by a short pyramid; $I \wedge I=91^{\circ} ; 1 \wedge 1$ over $x=143^{\circ} 20^{\prime}$. Also in globular, stellated, and divergent groups, consisting of delicate acicular fibres, the fibres often terminating in acicular prismatic crystals.

Color white, or inclining to yellow, gray, or red. Lustre vitreous. Tramsparent to translucent. $\mathrm{H} .=5-5.5 . \quad \mathrm{G} .=2 \cdot 17-2 \cdot 2$. Brittle.

Composition. $\mathrm{Na}_{2} \mathrm{Al}_{10} \mathrm{Si}_{3}+2 \mathrm{aq}=$ Silica
 $47 \cdot 29$, alumina $26 \cdot 06$, soda $16 \cdot 30$, water $9 \cdot 45=100$. B.B. fuses casily and quietly to a clear glass ; a fine splinter molts in a candle flame. Decomposed by hydrochloric acid, and the solution gelatinizes on evaporation.

Diff. Distinguished from seolecite by its quiet fusion.
Obs. Found in amygdaloidal trap, basalt and volcanic rocks; sometimes in seams in granitic rocks. The name natrolite is from natron, soda.

Occurs in Bohemia; Auvergne; Fassathal, Tyrol; at Glen Furg in Fifeshire; in Dumbartonshire ; Nova Scotia ; Bergen Hill, N. J.
Scolecite. Resembles natrolite, and differs in contnining lime in place of soda; also in having its slender rhombic glassy prisms longitudinally twinned, as is shown by the meeting of two ranges of strixe at an angle along or near the central line of opposite prismatic planes. The lustre is vitreous or a little pearly. B.B. it curls up like a worm (whence the name from the Greek skolex, a wourn) and then melts. From Staffa, Iceland, Finland, Hindostan.

Mcsolitc. Another related species.

## Analcite.

Dimetric or Trimetric. Occurs usually in trapezohedron (fig. 1, also fig. ${ }^{2}$ ).


The appearance sometimes seen in polarized light is shown in figure 7, page 69. On account of this peculiar behavior and indications of a compound structure obtained in a microscopic study
of thin slices, it has been suspected to be dimetric like leucite, or else trimetric like phillipsite, although the forms of the crystals are apparently isometric. Often colorless and transparent, also milk-white, grayish and reddishwhite, and sometimes opaque. Lustre vitreous. $\mathrm{H} .=5-5.5$. G. $=2 \cdot 25$.

Composition. $\mathrm{Na}_{2} 41 \mathrm{O}_{12} \mathrm{Si}_{4}+2 \mathrm{aq}=$ Silica $54 \cdot 47$, alumina $23 \cdot 29$, soda $14 \cdot 07$, water $8 \cdot 17=100$. B.B. fuses easily to a colorless glass. Decomposed by hydrochloric acid ; and the silica separates in gelatinous lumps.

Diff. Characterized by its crystallization, without clearage. Distinguished from quartz and leucite by giving water in a closed glass tube ; from calcite by its fusibility, and by not effervescing with acids; from chabazite and its varieties by fusing without intumescence to a glassy globule, and by the crystalline form.

Obs. Found in cavities and seams in amygdaloidal trap, basalt and other eruptive rocks, and sometimes in granite, syenyte and gneiss.

Occurs in fine crystallization in Nova Scotia; also at Bergen IIill, N. J.; Perry, Me.; and in the trap of the Copper region, Lake Superior. The Faroe Islands, Iceland; Olen Farg, near Edinburgh; Kilmalcolm, the Campsie Hills, and Antrim ; the Vicentine ; the Harts at Andreasberg ; Sicily, and Vesuvius, are some of the foreign localities.

The name analcite is from the Greek, challis, weak, allading to its weak electric power when heated or rubbed.

## Eudnophite. Near analcite. From Norway.

Faujasite. In isometric octahedrons. From the Kaisers!` 1, Baden.

## Chabazite.

Rhombohedral. Often in rhombohedrons, much resembling cubes. $R: R=94^{\circ} 46^{\prime}$. Cleavage parallel to R. Also in complex modifications of this form. Never massive or fibrous.

Color white, also yellowish, and flesh-red or red. Lustre vitreous. Transparent to translucent. H. = 4-5. $\quad \mathrm{G} .=2 \cdot 08-2 \cdot 19$.

The red chabazite of Nova Scotia has been called Acaricite.

Composition. $\mathrm{CaAlO} \mathrm{O}_{12} \mathrm{Si}_{4}+6 a q$, with a little $\mathrm{Na}_{2}$ or $\mathrm{K}_{9}$ in place of part of the Ca. The Nova Scotia acadialite afforded

Silica $52 \cdot 20$, alumina $18 \cdot 27$, lime $6 \cdot 58$, soda and potash $2 \cdot 12$, water 20.52 . B.B. intumesces and fuses to a nearly opaque bead. Decomposed by hydrochloric acid, with the separation of slimy silica. In the closed tube gives water. Phacolite is a varicty in complex glassy crystals.

Diff. The nearly cubical form often presented by the crystals of chabazite is a striking character. It is distinguished from analcite as stated under that species; from calcite by its hardness and action with acids; from fluorite by its form and cleavage, and its showing no phosphorescence.

Obs. Found in trap and occasionally in gneiss, syenyte, and other rocks. Chabazite is met with in the trap of Connectient Valley, but in poor specimens; also at Hadlyme and Stonington, Coun.; Charlestown, Mass.; Jergen Mill, N. J.; Piermont, N. Y.; Jones's Falls, near Baltimore (Haydenite). Nova Scotia affords common chabazite, and also the acadialite in abundance. The Faroe Islands, Iceland, and Giant's Causeway, are some of the foreign localities; also the County of Antrim, Ireland.

Herselclite. Near chabazite, if not identical with it. From Sicily.
Gmolinite. Closely resembles some chabazite, but its crystals are usually hexagonal rather than rhombohedral in appearance. Formula $(\mathrm{Na}, \mathrm{Ca}) \mathrm{Al}_{2} \mathrm{O}_{12} \mathrm{Si}_{4}$. A Bergen IIill specimen afforded Silica $48: 67$, alumina $18 \cdot 72$, lime $2 \cdot 60$, soda $9 \cdot 14$, water $21 \cdot 35=100 \cdot 48$. Gelatinizes with hydrochloric acid, but in other respects resembles chabazite. Occurs at Andreasberg ; in Antrim, Ireland ; in Skye; at Bergen Hill, N. J. ; in Nova Scotia at Cape Blomidon. Named after the chemist, Gmelin.

Levynite (Levyne). Rhombohedral, and somewhat resembling gmelinite in iis crystals; excluding the water, having the quantivalent ratio of labradorite, $1: 3: 6$. Colorless, white, grayish, reddish. From Iceland, Greenland, Antrim, Londonderry, Hartficld Moss near Glasgow. Named after the crystallographer, Levy.

## Harmotome.

Monoclinic. Unknown except in compound crystals; and commonly in forms similar to the annexed figure ; also in compound rhombic prisms.

Color white ; sometimes gray, yellow, red, or brownish. Subtramsparent to translucent. Lustre vitreous. $\mathrm{II}=4.5$. G. $=2 \cdot 45$.

Composition. $\mathrm{BaAl} \mathrm{O}_{14} \mathrm{Si}_{5}+5$ aq $=$ Silica $46 \cdot 5$, alumina $15 \cdot 9$, baryta $23 \cdot 7$, water $13 \cdot 9=100$; but a little of the baryta replaced by potash. B.B. whitens, crumbles, and fuses quietly
to a white translucent glass. Gives water in a closed glass tube. Partially decomposed by hydrochloric acid, and if sulphuric acid be added to the solution,
 a heavy white precipitate of barium sulphate is formed. Some varieties phosphoresce when heated.

Diff. Its twin crystals, when distinct. cannot be mistaken for any other species except phillipsite. Much more fusible than glassy feldspar or scapolite; does not gelatinize in acids like thomsonite.

Obs. Occurs in amygdaloidal trap, and in trachyte and phonolyte, also in gneiss, and metalliferous veins. Fine crystallizations are found at Strontian in Scotland, and in Dumbartonshire; Andreasberg in the IIartz; Kongsberg in Norway. Has been found in seams in the gueiss of the upper part of New York Island.

The name harmotome is from the Cireck harmos, a joint, and temno, to cleare.

I'hillipsite. Near harmotome in its cruciform crystals and other characters; but differing in containing lime in place of baryta. It differs also in gelatinizing with acids and in fusing with some intumescence. It also occurs in sheaf-like aggregations and in radiated crystallizations. From the Giant's C'auseway, Capo di Bove, Vesuvius, Sicily, Iceland.

Epistibite. A hydrous silicate of alumina and lime. Occurs in thin rhombic prisms, of a white color, with a perfect pearly cleavage like stilbite. $H .=4-4 \%$ G. $=-2: 25$. Before the blowpipe froths and forms a vesicular cnamel. Does not gelatinize. Fros Iceland and Hindostan, and sparingly at Bergen IIill, N. J.
Bravaisite. Supposed to be a zeolite ; it has potassium, magnesium and iron as the protoxide bases.

## Stilbite.

In prramidally terminated rectangular prisms usually flattened parallel to the face $i-\check{c}$, which is the direction of cleavage and is very pearly in lustre. $1 \wedge 1=119^{\circ} 16^{\prime}$, and $114^{\circ}$. Also in sheaf-like aggregations, and thin lamellar and columnar ; also in pearly radiated crystallizations.

Color white; sometimes yellow, brown or red. Subtransparent to translucent. $H .=3 \cdot 5-4 . \quad$ G. $=$
 2-1-2•15.

Composition. CaAl O ${ }_{10} \mathrm{Si}_{6}+6 \mathrm{aq}=$ Silica $5 \% \cdot 4$, alumina $16 \cdot 5$, lime $8 \cdot 9$, water $17 \cdot 2=100$; but with a little $\mathrm{Na}_{2}$ or $\mathrm{K}_{2}$ in place of part of tho Ca. B.B. exfoliates, swells up, and curves into fan-like forms, and fuses to a white enamel. Decomposed by hydrochloric acid without gelatinizing.

Diff. It cannot be scratched with the thumb-nail, like gypsum. It is distinguished from heulandite by its crystals.

Obs. Occurs mostly in trap-rocks: also on gneiss and granite. Found on the Faroo Ids.; Isle of Skye ; Isle of Arran, and clsewhere, Scotland; Andreasberg, Hartz ; the Vendayah Mts., Hindostan. Found sparingly at the Chester and Charlestown syonite quarrics, Mass.; at New Haven, Thatchersville and IIadlyme, Conn., and other points in the Connecticut Yalley trap; at Phillipstown, N. Y.; at Bergen IIill, N. J.; in trap, in the copper region of Lake Superior ; in beautiful crystallizations at various points in Nova Scotia.

The name stilbite is derived from the Greek stillè lustre. It has also been called desmine, and in Germany houlandite, where heulandite has been called stilbite.

## Heulandite.

Monoclinic. In right rhomboidal prisms like the figure, with perfect pearly cleavage parallel to 1 and other planes vitreous in lustre. F' on M or $\mathrm{T}=90^{\circ} ; \mathrm{M}$ on ' T $=129^{\circ} 40^{\prime}$. Color white ; sometımes reddish, gray, brown. Transparent to subtranslucent. Folia brittle. H. $=3 \cdot 5-4 . \quad$ G. $=2 \cdot 17-2 \cdot 2$.

Composition. $\mathrm{CaAlO} \mathrm{O}_{16} \mathrm{S1}_{6}+5 \mathrm{aq}=$ Silica $59 \cdot 1$, alumina $16 \cdot 9$, lime $9 \% 2$, water $14 \cdot 8=100$. Contains 1 to 2 per cent. of $\mathrm{Na}_{2}$ or $\mathrm{K}_{2}$ in place of part of the
 Ca. Blowpipe characters like those of stillite. Intumesces and fuses, and becomes phosphorescent. Dissolves in acid without gelatinizing.

Diff. The very pearly lustre of the cleavage face is a marked characteristic. Distinguished from gypsum by its hardness ; from apophyllite and stilbite by its crystals; and from the lattor species also in not occurring in radiated crystallizations.

Obs. Found in amygdaloidal cavities and fissures in trap; occasionally in gneiss, and in some metalliferous
veins; in large crystallizations at Berufiord, Iceland; and Vendayah Mts.. Hindostan ; also at Isle Skye; near Glasgow ; Fassa Valley ; at Bergen Hill, N. J., in trap ; at Hadlyme, Conn., and Chester, Massachusetts, on gneiss ; near Baltimore, on a syenitic schist (Beazmontite); at Peter's Point and Cape Blomidon, and other places in Nova Scotia, in trap.
The species was named by Brooke after Mr. Heuland, of London.

Breoosterite. Crystals monoclinic with a perfect pearly cleavage like heulandite ; but $\mathrm{M}: \mathrm{T}=93^{\circ} 40^{\prime} . \quad \mathrm{H}=4 \frac{1}{2}-5 . \quad G .=245$. The formula is analogous to that of heulandite, but baryta and strontia tako the place of the lime and soda.

Epistillite. Composition like that of heulandite, but occurs in short and very obtuse rhombic prisms, ( $I \wedge I=135^{\circ} 10^{\circ}$ ), at Skye ; the Faroe Ids., in Iceland; at Margaretville, in Nova Scotia.
Mordenite. Fibrous mineral from Morden, Nova Scotia.
Pilinite. In slender ncedles, from Silesia.
Forcsitc. Near stilbite. From Elba.

## III. MARGAROPHYLLITE SECTION.

## Talc.

Trimetric. In right rhombic or hexagonal prisms. $I \wedge I$ $=120^{\circ}$. Usually in pearly foliated masses, separating easily into thin translucent folia. Sometimes stellate, or divergent, consisting of radiating lamme. Often massive, consisting of minute pearly scales; also crystalline granular, or of a fine impalpable texture.
Lustre eminently pearly, and feel unctuous. Color some siade of light green or greenish white; occasionally silvery white ; also grayish green and dark olive-green. $\mathrm{H}=1-$ 1.5 ; casily impressed with the nail. G. $=3 \cdot 5-2 \cdot 8$. Laminæ flexible, but not elastic.

There are the following varieties:
Foliated Talc. The pure foliated tale, of a white or greenish-white color.

Soapstone or Steatite. Gray or grayish green, and either massive, crystalline granular, or impalpable ; very greasy to the touch. French chalk is a milk-white variety, with a pearly lustre. Potstone or Lapis Ollaris is impure soapstone of grayish-green and dark-green colors, and slaty structure.

Indurated Tale, is a slaty talc, of compact texture, and above the usual hardness, owing to impurities.

Rensselaeritc. A compact crypto-crystalline rock, from St. Lawrence and Jefferson counties, N. Y., of white, yellow, or grayish-white colors, and even black. It has sometimes the form and cicavage of pyroxene, and is in part at least a product of the alteration of that mineral.

Composition. $\frac{1}{8} \mathrm{II}_{2} \frac{4}{3} \mathrm{Mg} \mathrm{O}_{3} \mathrm{Si}=$ Silica $62 \cdot 8$, magnesia $33 \cdot 5$, water $3 \cdot \%=100$. It usually contains a little iron replacing magnesium. B.B. infusible. Moistened with cobalt nitrate assumes a pink tint. Not acted upon by hydrochloric acid. In closed tube gives a little water, but not till highly heated.

Diff. The softness, unctuous feel, foliated structure, when crystallized, and pearly lustre of tale are good characteristics. It differs from mica also in bemg inelastic, although flexible; from chlorite, kaolinite, and serpentine in yielding little water when heated in a crlass tube. Only the massive varieties resemble the last-mentioned species, and chlorite has a dark olive-green color. Pyrophyllite, which cannot be distinguished in some of its varieties from talc, becomes dark blue when moistened with cobalt nitrate and ignited.

Obs. Oceurs in Cornwall, near Lizard Point; at Portsoy in Scotland; at Croky Mead, Ireland; in the Greiner Mountain, Saltzburg. Handsome foliated tale occurs at Bridgewater, Vt.; smithfield, R. I. ; Dexter, Me.; Lockwood, Newton and Sparta, N. J., and Amity, N. Y. On Staten lsland, near the Quarantine, both the common and indurated are obtained ; at Cooptown, Md., green, blue, and rose-colored tale occur. Steatite or soapstone is abundiant, and is quarried at Grafton, Vt., and an adjacent town ; at Francestown and Orford, N. II. It also occurs at Keene and Pichmond, N. II. ; at Marlboro' and New Fane, Vt. ; at Middlefield, Mass. ; in Loudon County, Va., and at many other places.

Steatite may be sawn into slabs and turned in a lathe. It is used for firestones in furnaces and stoves, and fire-places. It receives a polish after being heated, and has then a deep olive-green color. The finer kinds are made into images in China, and into inkstands and other forms in other countries. Potstone is worked into vessels for culinary purposes in Lombardy. The harder kinds are cut into gas jets. Steatite is also used in the manufucture of porcelain ; it
makes the biscuit semi-transparent, but brittle and apt to break with slight changes of heat. It forms a polishing material for serpentine, alabaster and glass. "French chalk" is used for removing grease-spots from cloth, as well as for tracing on cloth. When ground up, soapstone is employed for diminishing the friction of machinery.

## Pyrophyllite.-Agalmatolite, in part.

Near talc in crystallization, cleavage, its occurrence in fine-grained massive forms, its greasy feel, its white to palegreon colors, varying to vellowish, its feeble degree of hardness (1-2). The folia are sometimes radiated. G. $=\mathfrak{N} \cdot \pi \mathrm{T}^{2}$ 2.92.

Composition. An aluminous bisilicate, instead of a marnesian, for the most part of the formula, $A l \mathrm{O}_{9} \mathrm{Si}_{3}$. The Chesterfield, S. C., mineral afforded Genth, Silica 64.82, alumina $24 \cdot 48$, iron sesquioxide $0 \cdot 96$, magnesia 0.33 , lime $0 \cdot 55$, water $5 \cdot 25=100 \cdot 39$. B. B. whitens and fuses with difficulty on the edges. Gives a deep blue color with cobalt solution. Yields water in the closed tube. Radiated varietics exfoliate in fan-like forms.

Obs. Compact pyrophyllite is the chicf constituent of a kind of slate or schist, which is used for slate pencils, and hence is called pencil-stone. Occurs in the Urals; at Westana in Sweden ; in Elfdalen, with cyanite; foliated, in North Carolina, in Cottonstone Mountain; in South Carolina, in Chesterfield District, with lazulite and cyanite; Georgia, in Lincoln County, on Graves Mountain ; in Arkansas, near Little Rock; compact slaty in the Deep River region, N. C., and at Carbonton, Moore County; V. C.

## Sepiolite.-Mecrschaum of the Germans.

Usually compact, of a fine carthy texture, with a smooth feel, and white or whitish color ; also fibrous, white to blushgreen in color. $\mathrm{H}=2=2 \cdot 5$. The carthy variety floats on water.

Composition. $\frac{1}{3} \mathrm{H}_{2}^{2} \mathrm{P}_{3} \mathrm{Mg} \mathrm{O}_{3} \mathrm{Si}+1 \frac{1}{2} \mathrm{aq}=$ Silica $60^{\circ} 8$, magnesia $2 \% \cdot 1$, water $12 \cdot 1=100$. B. B. infusible, or fuses with great difficulty on the thin edges. Much water in a closed tube. A pink color with cobalt solution.

Occurs in Asia Minor in masses in stratified carthy deposits, and is extensively used for pipe bowls; also found in

Greece, Moravia, Spain, ctc. ; also in fibrous seams at a silver mine in Utah.

Aphrodite. Similar to the preceding. $\mathrm{Mg} \mathrm{O}_{3} \mathrm{Si}+\frac{3}{3} \mathrm{H}$. From Sweden. Cimolite, a clay from the Island of Argentiera, Fimole of the Greeks. Smectite, a kind of "Fuller's Earth," a name given to unctuous clays used in fulling cloth. Montmorillonite, Stolpcnite, and Stcargillitc, aro related clay-like minerals.

## Glauconite-Green Earth.

In dark olive-green to yellowish-green grains, or granular masses, with dull lustre. II. = 2. G. $=2 \cdot 2-24$.

Composition. Essentially a silicate of iron and potassium. Formula RR $\mathrm{O}_{12} \mathrm{Si}_{4}$, in which R is mainly Fe and $\mathrm{K}_{2}$ with sometimes Mg ; and B is Al, but sometimes largely Fe . Analyses give mostly $50-58$ per cent. silica, $20-24$ iron protoxide, 4-12 of potash and 8-12 of water. B.B. fuses easily to a magnetic glass. Yields water in a closed tube.

Obs. In a more or less pure state it forms thick beds in the Cretaceous formation, and also in the Lower Tertiary of New Jersey ; also occurs in other older rock formations down to the Lower Silurian. Found also, first by Pourtales, in the pores of corals and cavities of Rhizopod shells over the existing sea-bottom, showing it to be a marine product, and one now in progress of formation. The grains of the Cretaceons, Jertiary, and Lower Silurian beds have been shown by Ehrenberg to be the casts of the interior of shells of Rhizopods. The silica has been supposed to come from the siliceous secretions of a minute sponge growing in the cavities that afterwards became occupied by the glauconite.

Celadonite. A green earth with 53 per cent. of silica, from amygda. loid, near Verona. Probably an impure chlorite.
(Hloropal. A massive grecnish-vellow to pistachio-green compact mineral, somewhat opal-like in appearance, consisting chietly of silica, iron sesquioxide, and water. Montronite, Pinguite, Unghworite and Gramenite are varieties of it.

Stilpnomelane. Foliated and also fibrous, or as a velvety coating. Black to brownish and yellowish bronze in color and lustre. $\quad$. $=$ $3-3 \cdot 4$. Chietly silica and iron oxides, with 8 to 9 per cent. of water. Chalcodite of the Sterling Iron Mine, Antwerp, Jefferson County, N. Y., is here included.

## Serpentine.

Usually massive and compact in texture, of a dark oilgreen, olive-green, or blackish-green color ; also pale yel-
lowish-green, brownish-yellow and brownish-red. Occurs also fibrous and lamellar. The lamellar varieties consist of thin folia, sometimes scparable, but brittle ; colors green-ish-white, and light to dark green. Often in crystals pseudomorphous after chrysolite, chondrodite, and somo other minerals.

Lustre weak ; resinous, inclining to greasy. Finer varicties translucent; also opaque. $1 \mathrm{I} .=2 \cdot 5-4 . \quad \mathrm{G} .=2 \cdot 5-2 \cdot 6$. Feel somutimes a little unctuous. Tough. Fracture conchoidal.

Composition. A hydrous silicate of magnesium, like talc, but containing much more water and much less silica. $\mathrm{H}_{2} \mathrm{Mg}_{3} \mathrm{O}_{8} \mathrm{Si}_{2}+1 \mathrm{aq}=$ Silica $43 \cdot 48$, magnesia $43 \cdot 48$, water $13 \cdot 04=100$. B.B. fuses with much difficulty on thin edges. Yields water in the closed tube. Decomposed by hydrochloric acid, leaving a residue of silica. In some linds the Mg is replaced partly by Fe .
Specimens of a rich oil-green color, and translucent, breaking with a splintery fracture, are sometimes called precious serpentine, and the oparque kind, conmon serpentine.

Fibrous serpentine with a silky lustre is called Chrysotile, and also Amianthus. Unlike asbestus, which it resembles, it affords much water in a closed tube. Metaxite, Picrolite, and Baltimorite are coarse fibrous kinds. A foliated variety, from Hoboken, N. J., was named Marmulite, before it was known to be serpentine. Antigorite is a foliated variety. Williamsite is similar. Refdanskito contains nickel.
A porcelain-like serpentine-the Meerschamm of Taberg and Sala-has been called Porcelluploite; and a resin-like varicty, Retinalite and Vorhauserite.
Diff: The distinguishing characters are fechle lustre, somewhat resinous, compact structure, little hardness, being so soft as to be easily cut with a knife, and specific gravity not over $2 \cdot 6$.

Obs. Serpentine occurs as a rock, and the rescral varicties mentioned either constitute the rock or occur in it. Occasionally it is disseminated through granular limestone, giving the latter a clouded green color : this is the verd antique murble, called also Ophiolyte.
Serpentine occurs in Cornwall ; near Portsoy in Aberdeenshire, in Corsica, Siberia, Sasony, Norway at Snarum.

In the United States it occurs at Phillipstown, Port IIenry, Gouverneur, Warwick, N. Y.; Newburyport, Westfield, and Blandford, Mass.; at Kellyvale and New Fane, Vt.; Deer Isle, Maine ; New Haven, Conn.; Bare Hills, Md.; Hoboken, N. J. ; at Brewster's, Putnam County, N. Y., where it occurs psendomorphons after chondrodite, chlorite, enstatite, biotite, etc. ; in Canada at Orford, Ham, Bolton, etc.

Serpentine forms a handsome marble when polished, especially when mixed with limestone, constituting verdantique marble. Its colors are often beautifully clouded, and it is much sought for as a material for tables, jambs for fire-places, and ornamental in-door work. Exposed to the weather, it wears uneven, and soon loses its polish. Chromic iron is usually disseminated through it, and increases the variety of its colors. Near Milford and New Haven, Conn., a handsome verd-antique marble occurs which was formorly worked. $\Lambda$ white limestone, dotted and spotted with green serpentine at Port Henry, Essex County, N. Y.. is much esteemed for its beauty, and is now extensively worked. The name serpentine alludes to the varied green colors of such rocks.
Boverite from Smithfield, R. I., has the composition of serpentine, but the harduess 5.5-6, and the aspoct of nephrite, with $6 .-2 \cdot 59-2 \cdot 8$.

Bastite or Schiller Spar, is a foliated pyroxene or bronzite altered nearly to serpentine. Antillite is similar.

## Deweylite.

Massive. Whitish, yellowish, brownish-yellow, greenish, reddish, in color, with the aspect of grom arabic or a resin. Very brittle. II. $=2-35$. G. $=1 \cdot 9-2.25$.

In composition near serpentine but containing 20 per cent. of water. From Middlefield, Mass.; Bare Hills, Maryland ( (rymnite); Texas, Pa., and from the Fleims Valley, 'Tyrol.

Cerolite. Related to deweylite ; from Silesia. Limbachitc from Limbach, and Ziblitzite from Zöblitz, are similar.
Hydrophite. Like doweylite, but containing iron in place of part of the magnesium. From Taberg in Smaoland. Jenkinsite is a fibrous variety, occurring on magnetite, at O'Neil's mine in Orange County, N. Y.

Genthite or Nickel-gymnite. Similar to deweylite, but containing much nickel and G. $=2 \cdot 4$, analysis affording Silica $35 \cdot 36$, nickel protoxide $30 \cdot 64$, iron protoxide $0 \cdot 24$, magnesia $14 \cdot 60$, lime $0 \cdot 20$, water
$19 \cdot 09=100 \cdot 10$. From Texas, Pa.; Webster, N. C.; Michipicoton Island, Lake Superior; Malaga, Spain ; Saasthal, Upper Valois. Rottisite is similar.

## Saponite.

Soft, clay-like, of the consistence before drying of cheese or butter, but brittle when dry. Color white, yellowish, grayish-green, bluish, reddish. Does not adhere to the tongue.

Composition. A hydrous silicate of magnesia containing some alumina.
From Lizard's Point, Cornwall, in serpentine. Also from geodes of datolite, Roaring Brook, Comm. ; in tral, north shore of Lake Superior.

## Kaolinite.

Trimetric. $\quad I \wedge I=120^{\circ}$. Occurs massive, clay-like, lut consisting usually of thin, microscopic, rhombic or hexagonal, crystals ; either compact, friable, or mealy.

Color white, grayish-white, yellowish, sometimes brownish, bluish, or reddish. Scales transparent or translucent; flexible, inelastic, greasy to the tonch. II. $=1-2 \cdot 5 . \quad G .=$ $2 \cdot 4-2 \cdot 6$.

Composition. $\mathrm{II}_{4} \mathrm{Al} \mathrm{O}_{8} \mathrm{Si}_{2}+1 \mathrm{aq}_{1}=$ Silica $46 \cdot 4$, alumina $39 \cdot 7$, water $13 \cdot 9=100$. The similarity of the composition to that of serpentine will be seen on comparing the two formulas. B. B. infusible. A hue color with cobalt solution. Tields water in the closed tube. Insoluble in acids.

Obs. The soapy feel of kalinite distinguishes a clay consisting of it from other kinds of clay; and when common clays are "unctrous" it is usually owing to the presence of kaolinite. Kaolinite has been made through the decomposition of aluminous minerals, and especially the potash and soda foldspars, orthoclase, albite, and oligoclase. In the case of these feldspars the process (1) removes the alkalies; ${ }^{(2)}$ ) leaves the alumina, or a large part of it, and part of the silica; and (3) adds water. So that, with orthoclase, $\mathrm{K}_{2} \mathrm{Al}$ $O_{18} \mathrm{Si}_{6}$ becomes changed to $\mathrm{IH}_{2} \mathrm{Al} \mathrm{O}_{8} \mathrm{Si}_{2}+1 \mathrm{aq}$; half the water which is added replaces $\mathrm{K}_{2}$ which is removed. Many granites, gneisses, and other feldspar-bearing rocks undergo rapidly this change, so that extensive beds of kaolinite have been formed and are now making in many regions. The kaolinite is usually washed out by streams or the waves from the decomposed material to make the large pure deposits.

The New Jersey clay-beds of the Cretaccous formation are mainly kaolinite, and have been thus formed. In other cases permeating waters have washed out the oxides of iron present, and have left the white clay in place. A pure kaolinite bed occurs at Brandon, Vermont, along with a limonite bed, where the rock decomposed was probably a feldspathic hydromica slate. Most of the limonite beds of Western New England afford kaolinite ; yet it is generally more or less colored by iron oxide.

Common clays consist of fincly-powdered feldspar, quartz, and other mineral material, with often more or less kaolinite. They burn red in case they contain iron in the state ordinarily present in them of iron carbonate, or hydrous iron oxide (limonite), or in combination with an organic acid, or in some other alterable state of composition, heat driving off the carbonic acid or water, or destroying the organic acid, and so leaving the red oxide of iron (or sesquioxide), or favoring its production. But the iron may be so combined as not to give the red color; and this has been found to be true with the clays from which the cream-colored Milwakee (Wisconsin) brick are made, and that of other clay beds in that vicinity. The iron may bo there in the state of the silicate, zoisite, or epidote.

Puro kaolinite (or koolin as it is ordinarily called) is used in making the finest porcelain. For this purpose it is mixed with pulverized feldspar and quartz, in the proportion needed to give, on baking, that slight jncipient degree of fusion which renders porerlain transluecnt. The name kaolin is a corruption of the Chinese word hauting, meaning high ridge, the name of a hill near Janchau-Fu, where the mineral is obtained; and the petuntze (peh-tun-tsz) of the Chinese, with which the kaoln is mixed in Chima for the manufacture of poreclain, is, according to S. W. Williams, a quartzose feldspathic rock, consisting largely of quartz. The word porcelain was first given to China-ware by the Portuguese, from its resemblance to certain sea-shells called lorcellana; they supposed it to be made from shells, fishglue, and fish-scales (S. W. Williams).

The impure kaolin is used for stoneware and fire-bricks. The presence of iron, in any state, makes a clay more or less fusible, and therefore an unfit material for fire-bricks. But a little of it exists in all clays employed for making ordinary bricks, and hence their red color.

Pholerite, Hailoysilc, Smertite, Sevcrite, Glagerite, Lenzinite, Bole, Lithomarge, are names of clay-like minerals.

## Pinite.

Amorphons, and usually cryptocrystalline ; but often having the form of the crystals of other minerals from the alteration of which it has been made. Colors grayish, greenish, brownish, and sometimes reddish. Lustre fceble; waxy. Translucent to opaque. Acts like a gum on polarized light, and thus indicates the absence of true crystallization, even when under the forms of crystals. $\mathrm{H} .=2 \cdot 5-3 . \mathrm{G} .=2 \cdot 6-2 \cdot 85$.

Composition. Mostly $\left(\mathrm{H}_{3} \mathrm{~K}\right)_{2} \mathrm{Al}_{2} \mathrm{O}_{2 n} \mathrm{Si}_{5}$. The pinite of Saxony afforded Silica 46.83 , alumina $27 \cdot 65$, iron sesquioxide $8 \cdot 71$. magnesia $1 \cdot 02$, lime $0 \cdot 49$, soda $0 \cdot 40$, potash 6.52 , water $3 \cdot 83$ $=99 \cdot 42$; and, in another analysis, potash $10 \cdot \% 4$. The physical characters ally it to serpentine, and also nearly the atomic ratio, and it may be viewed as a potash-alumina serpentine. But at the same time it has very nearly the composition of a hydrous potash mica, or damourite (see next page).

Obs. The varieties are pseudomorphs after different mincrals, and hence comes a part of their variations in composition. They include Pinite, from the Pini Mine, near Schneeberg and elsewhere ; Gieseckite, pseudomorph after nephelite from Greenland, and from Diana, N. Y.; Dysyntribite, from Diana, identical with gieseckite ; Pinitoid, from Saxony ; Hilsonite, from Bathurst, Canada, having the cleavage of scapolite; Terenite, from Antwerp, N. Y., like Wilsonite ; Agalmatolite, or Pagodite, from China, being one of the materials for carving into images, ornaments, models of pagrodus, etc.; gigantolite and iberite, which have the form of jolite.

Polyargite, Rosite, Cataspilite, Biharite are related materials.
Palagonite. Yellow to brownish yellow. garnet-red to black in color, and resinous to vitreous in lustre. The material of some tufas, and the result of change through the agency of steam or hot water at the time, probably, of the deposition of the material. From tufas of Iceland, Germany, Italy, Sicily, and named from Palagonia, in Sicily.

## HYDROMICA GROUP.

The following species are mica-like in clearage and aspect, but talc-like in wanting clasticity, greasy feel, and pearly lustre. They are sometimes brittle. Common mica, mus-
covite, readily becomes hydrated on exposure ; but hydrous micas are not all a result of alteration. The Hydromica slates form extensive rock-formations, equal to those of the ordinary mica schists. They were for the most part called Talcose slates (or Tall-schiefer in German) from their greasy feel, until the fact was ascertained that they contained no magnesia : a point demonstrated for the Taconic slates of the western border of Massachusetts, by C. Dewey, in 1819, and later, by (. F. Barker, for those of Vermont. Pinite is related in composition, but is not micaccous.

## Margarodite.

Like muscovite (page 267 ), but inclastic.
Composition. Specimens from the topaz vein, Trumbull. Conn., afforded Silica 4650 , alumina $33 \cdot 91$, iron sesquioxide $2 \cdot 69$, magnesia $0 \cdot 90$, soda $2 \cdot \%$, potash $7 \cdot 32$, water $4 \cdot 63$, fluorine 0.82 , chlorine $0.31=99.78$. Another from Litchfield, Conn., accompanying cyanite, afforded water $5 \% 6$ per cent., sola $4 \cdot 10$, potash $6 \cdot 20$, showing a large percentage of soda. It is probable that both of these micas were originally hydrous.

## Damourite.

Mica-like, consisting of an arroregation of fine pearly scales, yollow to white in color.

Composition. Near margarodite, being a hydrous potash mica. A specimen from Jrittany afforded Silica 4502 , alumina $3 \% \cdot 85$, potash $11 \% 0$, water $5 \cdot 25=99 \cdot 5 \%$. The quantivalent ratio for the protoxide, sesquioxide, silica, and water is 1:9:12:2, instead of that of margarodite, which is 1:6:9:2. A schistose hydromica slato from Lehigh County, Penusylvania, afforded Dr. Genth, Silica 49092 , alumina $34 \cdot 06$, iron sesquioxide $0 \cdot 91$, magnesia $1 \cdot \% \%$, lime $0 \cdot 11$, soda $0 \% 4$, potash $6 \cdot 94$, water $6 \cdot 52=100.9 \%$.

Obs. From a locality of cyanite in Brittany, and another in Warmland ; also the constituents of a gametiferous schist at Salm-Chateau, in Belgium ; and in part, of extensive schistose formations in Vermont, Western Massachusetts, Western Connecticut, and also just west of Now Haven, Connecticut ; Eastern Pennsylvania, ctc.

For other analyses of hydromica slates, see Dr. Genth's report on the Mineralogy of Pennsylvania; also Geological Report of F. Prime, Jr., for 1874, p. 12.

Parophite. The material of a schist or slate-Parophite Schistwhich cuts like massive talc, is of greenish, yellowish, reddish, and grayish colors, and is probably a danourite or hydromica slate, with some free silica (quartz). An analysis afforded Silica 48.46 , alumina $27 \cdot 55$, iron protoxide $5 \cdot(18$, magnesia $2 \cdot 02$, lime $2 \cdot 05$, soda $2 \cdot 35$, potash 516 , water $714=99.81$. It is from Pownal, Vt., and St. Nicholas, Stanstead, and other neighboring parts of Canada.

Sericitc. A damourite-like mineral, with the pearly lustre of tale, and the composition of a hydrous mica; it is the basis of a glossy schist ; near Wiesbaden. The scales are described ly Rosenbusch as appearing fibrous when highly magnified. Analysis afforded Silics $49 \cdot 00$, alumina $28 \cdot 6 \pi$, iron protoxide 8.07 , magnesia 0.94 , lime 0.63 , soda 1.75 , potash 9.11 , water 3.47 , titanic diozide 1.30 , silicon lluurido $1 \cdot 60=100 \cdot 14$.
Paragonite. A hydrous mica containing soda in place of potash. From Mount Campione, in the region of St. Qothard. Color whithsh, grayish, yellowish, greenish. Analysis afforded Silica 46.81, ulumina 4006 , magnesia 065 , lime $1 \% 4$, soda 640 , potash trace, water $4.82=100$. Pregrattite. from the Tyrol, afforded soda 7.06 , potash 1.71, water 504 ; it exfoliates like the Vermiculites. Cossute is here included.

Groppite. A rose-red to brownish-red folinted mincral from Gropptorp, Sweden.

Enphyllite. Mica-like, with folia rather brittle, pearly lustre, white or colorless. Contains much sodium. An analysis afforded Silica $41 \cdot 6$, alumina $42 \cdot 3$, lime $1 \cdot 5$, potash $3 \cdot 2$, soda $5 \cdot 9$, water $5 \%=100$. Occars with corundum at Unionville, Delaware County, Pa.

Gellacherite. Mica-liko; strong pearly in lustre, grayish white to white ; elastic. Analysis obtaiued 7.61 potash, $1 \cdot 42$ suda, $4 \cdot 6 \mathrm{j}$ baryta, and $4 \cdot 43$ water, besides silica, alumina, etc.

Cooleite. In minute mica-like seales, and in slender six-sided prisms. Affords only $2 \cdot 57$ of potash, with $2 \cdot 82$ of Iithia; the water 13.41 per cent. Occurs on crystals of red tourmaline at Hebron and Paris, Me, and has procoeded from its alteration. Named after Prof. J. P. Cooke, of Cambridge, Mass.

Voigtite is the mica of a granite at Ehrenberg, near Ilmenau, whic 1 has the composition of biotite, plus 9 to 10 per cent. of water.

Roscoelitc. A vanadium-mica, of dark brownish-green color, occurring in micaceous scales, and affording over 20 per cent. of vanadium oxides, along with $47 \cdot 69$ of silica, $14 \cdot 10$ of alumina, 7.59 of potash, 496 of water, and a little magnesia and soda. From Granite Creck Gold Mine, El Dorado County, California.

## Fahlunite.

In six and twelve-sided prisms, usually foliated, parallel to the base, but owing its prismatic forms to the mineral from which it was derived. Folia soft and brittle, of a
grayish-green to dark olive-green color, and pearly lustre. ( $\mathrm{t} .=2 \cdot \%$ 。

Composition. A hydrous silicate of aluminum and iron with little or no alkali, and in this last point differing from pinite. An average specimen afforded Silica $44^{6} 60$, alumina $30 \cdot 10$, iron protoxide $3 \cdot 86$, manganeso protoxide $2 \cdot 24$, magnesia $6 \%$, lime 1.35 , potash 1.98 , water $9.35=100 \% 3$. B.B. fuses to a white glass. In a closed tube gives water. Insoluble in acids.

Diff. It is distinguished from tale by affording much water before the blowpipe, and readily ly its association with iolite, and its large hexagonal forms, with britte folia.

Obs. Fahlunite has been derived from the alteration of iolite. The quantivalent ratio of iolite for the protoxides, sesquioxides, and silicon is $1: 3: 5$; and for fahlunite, the same, with 1 for the water, making the whole 1:3:5:1. The hydration appears to go on at the ordinary temperature, and in some localities all the iolite to a considerable depth in the rock is changed to fahlunite. There are different varieties, depending on the amount of water, and the conditions under which the change has taken place. The names they hare received are Hydrous Iolite, Chlorophyllite, Esmarkite, Aspasiolite, Pyrargillite, Iriclasitc. Fidhilunite was so named from its locality, Fahlun, Sweden ; and Chlorophyplite from its greenish color and foliated structure ; the specimens to which it was given occurring at Unity, N. IF. Haddam, Ct., is another locality. Gigantolite, Iberite, are also altered iolite, but they contain potash, and belong hence to the Pinite Group.

## Hisingerite.

Massive ; reniform ; of a black to hrownish-hlack color. vellowish-brown streak, greasy lustre inclining to vitreous. $\mathrm{H} .=3 . \quad \mathrm{G} .=3 \cdot 045$.

Composition. A hydrous iron silicate. Silica 35.9, iron sesquioxide $42 \cdot 6$, water $21: 5=100$. But in some analyses part of the iron is in the protoxide state. B.B. fuses with difficulty to a magnetic slag.

Obs. From Sweden, Norway, Finland. Scotiolite and Degeröite are referred to it. Melanolite, from Milk-Kow quarry, near Charlestown, Mass., is related in composition, if the material analyzed was a pure species.

Approaches in composition the chlorites, and may belong to that group.

Gillingite from Sweden, including Thraulite from Bavaria, Epichlorite, and Lillite, are other hydrous silicates containing iron.

L'kmannite, foliated, chlorite-like, occurs in the rifts of magnetite, in Sweden; it is a hydrous iron silicate, but the iron is mostly in the protoxide state.

Neotocite (Stratopeite) and Wittingite are results of the alteration of rhodonite, and contain manganese. Stübelite also contains manganese oxide.

Strigovite from Striegau, Siberia, and Jollyte from Bodenmais in Bavaria, are hydrous silicates of aluminum and iron, with little magnesium.

## CHLORITE GROUP.

The chlorite group includes the hydrous Subsilicates of the Margarophyllite Section and also some related species that are Unisilicates. The proportion of silica is small, the percentage afforded by analyses being under 38 , and mostly under 30 . The mincrals when well crystallized are foliated like the micas, and hare the plane angle of the base of the crystals $120^{\circ}$, but the folia are inelastic and in some species brittle. They also occur in fibrous and in fine granular and compact forms, and the latter are usually most common. Green, varying from light to blackish green, is the prevailing color, yet gray, yellowish, reddish, and even white and black also occur ; and the colored transparent or translucont are dichroic. The green color is owing to the presence of iron, and fails only in species containing little or none of it. All of the species yield water in a closed tube. The quantivalent (or combining-power) ratio for $R+\mathrm{l}$ and Si is, in the

$$
\begin{aligned}
& \text { Pyrosclerite subdivision........... } 1: 1 . \\
& \text { Chlorite subdivision............. } 1: \frac{4}{3}, 1: \frac{3}{4}, 1: \frac{1}{2} . \\
& \text { Chloritoid subdivision............ } 1: \frac{1}{2} \text { to } 1: \frac{1}{3} \text {. }
\end{aligned}
$$

The chlorite subdivision includes Penninite, Ripidolite and Prochlorite, together with some related dark-green to blackish-green species. Somo species of this subdivision characterize extensive rock formations, making chlorite
schist or slate ; and they give rise also to chloritic varieties of other rocks. Moreover, chlorite is a result of the alteration of pyroxene, hornblende, and some other iron-bearing minerals ; and pyroxenic igneous rocks, like doleryte, are often strongly chloritic (as revealed by the microscopic examination of thin transparent slices), in consequence of this alteration-but alteration that took place before the rock had cooled. Such green chloritic material, where the species is not determinable, has been called Firidite. The cavities in amygduloid are often lined, and sometimes filled, by a specics of chlorite, which was made from certain constituents of the amygdaloid in the manner just stated ; and the rocks adjuining trap dikes are at times penetrated by chlorite made in them by means of the heat, and the moisture contained in them or ascending with the erupted rock.

## Pyrosclerite.

Trimetric or monoclinic. Mica-like in clearage ; folia flexible, not elastic, and pearly in lustre. Color applegreen to emerald-green. $\mathrm{H} .=3$. $\quad$. $=2 \cdot \gamma 4$.

Composition. $\left(\frac{2}{3} \mathrm{Mg}_{3} \frac{1}{3} \mathrm{Al}_{2}\right)_{2} \mathrm{O}_{12} \mathrm{Si}_{3}+3$ aq $=$ Silica $38 \cdot 9$, alnmina $14 \cdot 8$, magnesia $34 \cdot 6$, water $11 \cdot \%=100$. B. B. fuses to a grayish glass ; gelatinizes with hydrochloric acid.

Obs. Occurs in serpentine, on Elba.
Chonicrite (Metaxoite) is related to the above in composition, but affurds 12 to 18 per cent. of lime.

## Vermiculite.

Mica-like in clearage. Grayish, brownish, and yellowishbrown in color. In aggregated scales. Also in large micaceons crystals or plates. Lamine flexible, not elastic. Lustre pearly.

Composition. $\mathrm{Mg}_{3}\left(\mathrm{E}_{\mathrm{e}, \mathrm{Al}}\right) \mathrm{O}_{19} \mathrm{Si}_{3}$. When heated it exfoliates, and when scaly-granular the scales open out into worm-like forms; and thence the name, from the Latin vermiculor, I breed worms; B.B. fuses finally to a gray mass. From Milbury, Mass.

Jefferisite is a similar mineral in composition and exfoliation, occurring in broad folia. Composition $8 \mathrm{Mg}_{3}{ }_{3}\left(\mathrm{Fe}_{2}, \mathrm{Al}_{2}\right) \mathrm{O}_{12} \mathrm{Si}_{3}$. From veins in serpentine in Westchester, Pa. Culsagceito from Culsagee, North

Carolina; Hallite from Lerni, Delaware Co., Pa.; Protovermiculite from Magnet Cove, Ark., are other micaceous hydrous unisilicates similar to vermiculite and jefferisite in exfoliation. Kerrite and Maconite are related to the above. They are from Franklin, Macon Co., North Carolina. Pelhamite is from Pelham, Mass.

## Pemninite.-Chlorite in part. Penninc.

Rhombohedral. Cleavage basal and highly perfect, micalike. Also massive, consisting of an aggregation of scales, and cryptocrystalline.

Color green of various shades; also yellowish to silverwhite, and rose-red to violet. Lastre pearly on clearage surface. Transparent to translucent. Lamine flexible, not elastic. $11 .=2-2 \cdot 5,3$ on edges. $G .=2 \cdot 6-2 \cdot 85$.

Composition. A specimen from Zermatt, in the Pennine Alps, afforded Silica $33 \cdot 64$, alumina 10.64 , iron sesquioxide $8 \cdot 83$, magnesia $34 \cdot 95$, water $12 \cdot 40=100 \cdot 46$. The rose-red, from Texas, Pa., gave Silica $33 \cdot 20$, alumina $11 \cdot 11$, chromium oxide $6 \cdot 85$, iron sesquioxide $1 \cdot 43$, magnesia $35^{\circ} 54$, water $12 \cdot 95$, lithia and soda $0 \cdot 28$, potash $0 \cdot 10=101 \cdot 46$. Other Texas specimens afforded 0.90 to 4.68 per cent. of chromium oxide. B.1B. exfoliates somewhat and fuses with difficulty. Partially decomposed by hydrochloric acid, and wholly so by sulphuric acid.

From Zermatt, Ala in Piedmont, the Tyrol, etc. Fïmonererite, Rhoduchrome, and Phodophyllite include the reddish variety from near Miask, Russia; Texas, Pennsylvania; etc. Psendomorphs after hornblende, named Loganite, have the composition of this species ; and so has the massive mineral called Pseudophite and Allophits.
Delessite. A fibrous mineral near the above in composition, rom amygdaloid at Oberstein.

Euralite is an amorphous chlorite near Penninite, from Eura, Finland; from amygdaloid.

Diabantite (Diabantochronyn) is a chlorite from amygdaloid. A Farmington (Conn.) specinen afforded Hawes, Silica 33.63, alumina 1084 , iron sesquioxide $2 \cdot 86$, iron protoxide $24 \cdot 33, \mathrm{MnO}$ and $\mathrm{CaO} 1 \cdot 11$, magnesia $16 \cdot 52$, soda $0 \cdot 33$, water $10 \cdot 02=09 \cdot 69$.

Chloropheite is a doubtful species of chlorite, from amygdaloid.

> Ripidolite.-Chlorite, in part.

Monoclinic. Similar in cleavage and mica-like character to penninite, and also in its colors, lustre, hardness and specific gravity.

Composition. A specimen from Chester Co., Pennsylvania, afforded Silica $31 \cdot 34$, alumina $1 \% 47$, chromium sesquioxide $1 \cdot 69$, iron sesquioxide $3 \cdot 85$, magnesia $33 \cdot 44$, water $12 \cdot 60=$ 100.39 . B.B. and with acids nearly like penninite. A varicty from Willimantic, Ct., exfoliates like verniculito and jefferisite.

Fotschubeite is a red variety from the Urals.
Clinochlore and Grastite are here included. Occurs at $\Lambda$ chmatovsk and elsewhere in the Urals; at Ala, Piedmont; at Zermatt ; at Westchester, Unionville and Texas, Pa.; at Brewster's, N. Y.

## Prochlorite.-Chlorite in part.

Hexagonal. Similar in clearage and mica-like characters to the preceding. Color green to blackish-green ; sometimes red across the axis by transmitted light. Laminæ not clastic.

Composition. A specimen from St. Gothard afforded Silica 25.36 , alumina $18 \cdot 56$, iron protoxide $28 \cdot 79$, magnesia $17 \cdot 09$, water $8 \cdot 96=98 \% 0$; and a North Carolina specimen, Silica $24 \cdot 90$, alumina $21 \cdot 7 \%$, iron sesquioxide $4 \cdot 60$, iron protoxide $94 \div 21$, manganese protoxide $1 \cdot 15$, magnesia $12 \cdot \%$, water $10 \cdot 59=100$. B.B. same as for preceding.

Lophoite, Ogcoite, Helminthe belong here. Occur at St. Gothard, at Greiner in the Tyrol, at Traversella in Piedmont, and many other places in Europe. Also at Steele's Minc, N. C.
Leuchtenbergite is a prochlorite with the base almost solely magnesium.

Aphrosiderite, Metachlorite are near the above in composition.
Voncrite is a pale-green earthy chlorite, from a magnetite mine in Berks County, Pa.
Oorundophilite is a chlorite near prochlorite in composition. Occurs with corundum at Asheville, N. C.

Grochauitc is from Grochau in Silesia.
Cronstcdite. Hexagonal, with perfect basal cleavage. Black. G. = 3.35 . Consists mainly of silica, iron oxides, and water, with a little manganese oxide. From Bohemia and Cornwall.

Thuringite. Another hydrous iron silicate, having $\mathrm{G}=3 \cdot 15-3 \cdot 20$, from Thuringia, and also Hot Springs, Arkansas, and near Harper's Ferry, on the Potomac. Pattersonite, from Unionville, Pa., is near it.

Margarite.-Emerylite. Diphanite. Clingmanite. Corundellite.
Trimetric. Foliated, mica-like. Lamine rather brittle. Color white, grayish, reddish. Lastre of cleavage surface
strong pearly and brilliant, of sides of erystals viaroous. $11 .=3 \div-5 . \quad(1 .=9.99$.

 on the eders.

Ots. Often associated with cormodum and diapore. Occurs in Asi: Minor ; at Sterzing in the Tyrol: in the Trals; in Vollage Grem, and Vmonulle. Va; in Buncombe Comaty, N. ©.; at Chester, Mase. Nimed from the Greck marguritos, a peart.

Willenrite is near margarite. Duthyitw is au alteration product of margarite.

Chloritoin-Masonite. Mhyllite. (Ittrelite.
Honoclinic or tridinic. ('leavag hasal, ferfect. MFo eorme foliatod massive: and in thin dissemmated scates (phylite or ottrehte). Britio.
color dark gray, ereeninh, whath. Lastre of chatare surfice somewhat perarly.


 phetely hy sulpharie armb.



 rates the "spangled moa stat," of Newport, R. I., and Sterling, (ionhen, cte., Matr:.

Stuhertitc. Orcurs in somewhat mica like, or thin foliatod forms, with perfect basal cleavare and lamnas britth, the color reddish or


 lent ratio for protoxides, sesfuioxides, silica, and water 6.9 .5 : ${ }^{\prime}$. From Amity, N. Y ; slateust, Vrals (Xanthophyilite); Vassa Valley (Branrwoitc and Disterrite).

## IV. IIYTROCARBON COMPOUNDS.

The following are the sulndivinoms here uad.
I. Simple llyblochbibas: Marsh-gras, Mmeral oils, and Mineral was.
 Ill. dephatem axb Mineral (oxas.

## 1. SMMPLE HYDROMABONS.

Marsh-Gas.-hight Carbureftid IJolumen.
Colorlese and inotorons ate in the provestate. Inflammathe, and hurne whth a shlow flame Sompontion (dI, (arbon "in, hadracen $8=10 \mathrm{n}$.





 the explomat on mimes, a misther of it whth the atmor -phere aphomer on the appowh of the lhame of at an-






 abo for wher purpors where hat is mpaned.


 of the mone abmatant malle of teromponithom, whether


 bhants.

## Petroleum.


 of the Naphthat Ethytome serves. The compoxitinn of
 fommala. (" ${ }^{2} H_{2 n}+3$, of which Mar-haras si the firet an lownet term : and that of the Bohleme sursers he for-
 oils bary greatly in density from the hghtere naphtha, wo
inflammahe for we in lighting, to thick viscid fluids ; and thence they pase by insembbe gradations into anphaltum or solid bitmene The Marsh-gats arries contains abso crases, of the compurion ( ${ }^{\circ} \mathrm{I}_{6}$ and $\mathrm{G}_{3} \mathrm{H}_{8}$ and theste, $m$ adhition to Marsh-ats, often exist in commethon with petroknum.

Jetroleum oceurs in rocks of all ages, from the Lower Silurian to the most recent; in limestones, the more compact randstones, and shates; bat it is mostly ohtained from haren cabties or caverns wating among the carth's strata. Bhaks :halesand much botummous cond afford it abundantly when they are heated. But the oil ohtamed is not present in these rocks, for when the rocks are treated with benzme, the benzine takes "p lititur orone: insterad, the recks sontain an insoluble hydrocarbon, which yoteds the on when heat is aphed.

In the Enited States the oil, or the hempocamon which


 an at Cuha. Allechany Combli, N. Y., called Someca Oil Guming ;and on a largo seale in Santa Babam, Southern Cahfornia; at Kamoon m Burmah, where there are about 100 walls: ; 1 the moninsula of Apheron, on the Caspan, and (lsewhere. Pliny mentions the oil spring of Agrogentum, Sirity, and sibs: that the liquid was collected and uned for hurning in lamps as a subtitute for oil. Moreover he distmonishes the on from the lighter and more combustable naphtha, a localny of which about the sources of the Jndus, " in Parhia," he mentions.

Gotpolemm is ohtand chanfy at the prevent time from more or bess derply-sated sulterament hambers or cavities amomer the rook stratat redhed hy boring. Boing under pressure of ans associatcel with it, and atho, in many cases, that ahoo of water, it rises to the surfiece in the bormg, and sometumes makes a "sponting" well. As early as 1833 , Hildreth mentioned the diseharge of oil with the waters of the salt wrils of the Little Kanawhat valley; and speaks ako of a well near Marmeta, Ohio, which threw ont at one time, hesays, io to bo qallons of oil at "eath ermption."

The mineral of of the rocks has heen formed through the deeromposition of animal and veretable substances. From tho nature of the rocks which most abound in the species of hydrocarbons that geed oil, it is evident that
the rock material was in the state of a fine mud; that through this mud much vegetable or animal matler was distributed, almost in the condition of an emulsion; that the stratum of this mad becoming afterward ovelad by other strata, the deemmosition of regetable or animal matter went forward whout the presence of atmospherie air. or with only very litile of it. Under such direumsimers ather recetahle material or animal onds might be conserted. as chemests have shown, into mineral oil. Dry wood (onsista apporomately (exclading the ash and nitrogen) of if atoms of carbon to 9 of hydrogen, and 4 of oxyern. If now all the oxsen of the wood combmes with a part wh the car-
 moved, there will be left $\mathrm{O}_{4} \mathrm{H}_{3}$; twice this, $\mathrm{C}_{8} \mathrm{H}_{12}$, is the formula of a compond of the Marsh-gas or Naphtha serpe. Agam animal oils, by decomposition under somilar eircumstames, produce like results. Removing from oleme
 1 of rathome acid-bhere is left $\mathrm{C}_{3} \mathrm{H}_{\mathrm{a}}$, which is an oil of the Ethene series ; and margare adid would lave, in the
 or Naphindseries. Warren and Nower have ohtained from
 fion by lime, sereal compomats of the Marnheras serine, bo sudes others of the Ethyture and lenzole series. The docompositions in nature may uot have heen as smple as thowe in the aboro bllustratoms, yet the facte warmat the infirence that the oils may have been derived cither from rearetahle or amimal maters. Fossil fishes are often fomm abmo dantly in hatk oil-yiohmeg shales, and Dr. Newhery has sugerested that fishoil may be the most aboudant souree of the on and the oil-yieddng hydrocarbons.

Ithe wit which is eollected in ereat cavities amom.e the carthes strata, as in Western Pemsyltania, is beherent by most writers on the subject to have come from underlymis rochs, such as the back oil-yidding shales. The heat produed in the rochs by the frection attending movements and uphfte. se supposed to have beensuffecent to have mate the oil from the hydrocarbon of the carbonaceous shate or wher rock, atad to have camed it to ascend amoner the stata to the carities where it was comdensed, and now is fomed by boring.

The oils, exposed to the air and wind, undergo change in
thee wars first: the lighter maphthas evaporate, leaving the denser oils behind ; and, uffmaty, the varid hatumens, or else paraffin, aerording as parafin is present or not in the mativeoil. At the maphtha ishand of Trschetekin in Persia, there are large quantites of Vifteril, as it is called, which is neatly pume paratlon. 'The hot elmate of the ('aspain is farmahle for such a result. Semully: ther cmay be a hose of hadrogen from its combination with the oxyen of the atmophore form water, wheh eneapes. Thas the onds oi the Xaphtha series may whane mothose of the Ethylearem lenande somes. Thirdly: there may be an ovatation
 mote coal-like substanes. like albertite.

The word maththe is from the Perith, mefute, wesmbe; and perolemm trom the (iverk, petom, roch, and the Latm. wheu". onl.

Hachettite. - Mountaia Tallow. Ihatehetinr
 "hate to oreminh-y llow color.
(humpertion。 Rolaterl to parafin.

Oene rit is ike was ur upermaceti in comsintence Soluhl incther. The oricinal wav tom Mohavia. Along woth anothe was-like sul. stance, called liguthte, it constitates the " mineral wax of Itrpeth
 from Moldavia.

## Elaterite-Mineral Coonchouc Ehwic Bitumen.

In whf flexible manes, somewhat restmblay (:unduhne


 low flame and bummons olor.
(H) . From a lead mine in Derbshire, Enalam, and a coal mine at Montredas. It has hecinfonm at Woodbury, (t., in a himminnas limestone.
to and Inctite are reystallized hydrocarbons, of the Camphene series. Mrouchite, Dintit, and Irolytr are related to Martit. Komlite, Naphthotin, and Idriolite are native speries of the Benzole series. Areyotia, Presu California, is near Idrialite.

## II. OXYGENATED HYDROCARBONS.

## Amber.

In irregular masces. Color pollow, sometimms lnowni-h or whitin; lowe ressous. J'ransparent to translucent. H. $=2.20$ ( $2=1 \cdot 18$. Electric by friction.
 per (ent.) of a resin wheh resists all solvents, (alled siencrinite and two other reins colable in alcohol and ether,


















 the then vecol- foin, and werkmally a he we where







It almus of a zeroed pold and is uxed for ornamental purpess, thomeh mot very murh restermol, an it so watilue in hardness and hothamey of hatre and moreoner is andy imitaterl. It is monch sahued on Tanhey for month-pmen; (1) (iines.

Copulite, or Mineral Copnal, Widhomite, Andrite the New Zealand resin), Bussmite, Selertemite, Muddetete are some of the mames of other fossil resins: focorrite, and cremyricite, of wav-like oxymenatel


California), of species not resinous in lustre; Tasmanite and Dysodile, of kinds containing several per cent. of sulphur. Wollongongite, frum Australia, is black, and looks like cannel coal.

## III. ASPIALTUM AND MINERAL COALS.

## Asphaltum.

Amoryhous and pitch-like. Burning with a bright flame and melting at $90^{\circ}$ to $100^{\circ} \mathrm{F}$. Soluble mostly or wholly in (amphene. It is a misture of hydrocarbons, part of which are oxygenated.

Ots. Asphaltum is met with abundantly on the shores of the Jead Sea, and in the neightorhood of the Caspian. A remarkable locality occurs on the island of Trinidad, where there is a lake of it about a mile and half in cireumference. The bitumen is solid and cold near the shores; but gradually increases in temperature and softnoss toward the centre, where it is boiling. The appearance of the solidified bitunen is as if the whole surface had boiled uj) in large hubbles and then suddenly cooled. The aweent to the lake from the sea, a distance of three guarters of a male, is corared with the hardened piteh, on which trees and regetation flourish, and here and there, about Pont La Rraye, the masses of pitch look like black rocks among the foliage. It oceurs also in South America about similar lakes in l'ern, where it is nsed for pitching boats ; and in California on the coast of Santa Bartara. Large deposits oceur in sambstone in Albama. It is aho fomed in Derbyshire, and with quartz and flaor in gramite in Gornwall, and at many other phacos.

## Albertite,

Coal-like ju hardness, but littlo shluble in camphene, and only imperfectly fusing when heated; but having the lustre of asphaltrm, and softens a little in boiling water. $11=1-2$. ( $\mathrm{i} .=1.09 \%$.

Fills fiscures in the Subcarboniferous rocks near Millnborough, Nova Scotia, and supposed to have been derived from the hydrocarbon of the adjoining rock, and to have been oxidized at the time it was formed and filled the fismare.

Grahomitc is a related material from West Virginia, 20 miles south of Parkersburg. H.-2. G. 114.5 . Soluble mostly in camphene, but melts only imperfectly. An analysis afforded carbon 76.45 , hyurogen $7 \cdot 2$, oxygen (with traces of nitrogen) $13 \cdot 44$, ash $2 \cdot 26=100$.

## MINEIRAL COAL.

Massive. Color lalack or brown ; opaque. Brittle or imperfectly sectile. $\quad I I=0 \cdot 5-2 \cdot 5 . \quad G .=1 \cdot 3-1 \cdot 80$.

Composition. Carbon, with some oxygen and hydrogen, more or less moisture, and traces ahso of nitrogen, besides some earthy mineral which constitutes the ash. The carbon, or part of it, is in chemical combination with the hydrogen and oxygen.

Coals differ in the amome of volatile ingredients given off when heated. There ingredients are moisture, and hydrocarbon oils and gas, deriwal from the same class of insoluble hydrocarbons that is the souree of the cil of shates and other rocks.

## VAIREMTES.

1. Anthromite. Anthracite (called also glance coot and stone coul) has a high lnstre, and is often irdescent. It is quite compact and hard, and has a specific gravity from $1 \cdot 3$ to $1 \cdot \% 5$. It usually contains 80 to 93 per cent. of carbon, with 4 to 7 of whatile matter ; the rest consisting of carthy impurities. Burns with a feeble blue fame.

Those viedding the most rolatile ingredients are callod frecthorning anthrachte.
2. Butuminozes ('oth. Bituminous cond raries much in the amount of oll, coal-tar, or gats it jelds when heated; amd there is a crambal passage in its tarieties through semianthrocito to anthracite. It is of a black color, with tho powler black, but it is softer than anthracite, amd less lastrons. The specifie gravity does not exemed 1 . . Tho volatile ingrodients constitute usually between 20 and 40 per cent.

Caking Coal includes that part of bituminous conl which softens when heated and becomes viscid, so that adjoining pieces unite into a solid mass. It burns readily with a lively yellow flame, but requires frequent stirring to prevent, its agglutinating, and so clogging the fire. Nom-coktnef coal resembles the caking in appearance, but does not roften and ake. The chemical difference between caking and noncaking coal is not understood.
3. Cannel Coal is very compact and even in tevture, with little lustre, and breaks with a large conchondal fracture. It takes fire radnly, and burns without moltmers to a clear yol-

The following aro average results, from many analyses:


The orlinary impuritics of coal, makince up its ash, are sisica, a little potash and soda, and sometimes alumina, with often oxide of iron, derived usually from sulphide of iron; hesides, in the less pure kinds, more or less clay or shale. The amount of ash does not ordinarily exceed 6 per cent., but it is sometimes 80 per cent.; and rarely it is less than : pre cont. When not over 3 or 4 prr eant the whele nay have come from the plants which contributed the most of the material of the coal, since the Lycopods have much alumina in the ash, and the Equiseta much silica.

There is present in most coal traces of sulphide of iron (pyrite), sufficient to give sulphur fumes to the gases from the burniug coal, and sometimes enongh to make the coal valueles; in motallurgical operations. Some thin layer are occasionally full of concretionary pyrite. The sulphur was derived from the plants or from anmal life in the waters. Sulphur also ocrurs, in some coal beds, as a eonstituent of a resinous substance ; and Wormley has shown that part of the sulphar in the Ohio coals is in some analogous state, thero beines not irom cnough present to take the whole int. combination.

The average amount of ash in eighty-cieht coals from the southern lalf of Ohio, according to Wormley, is $4: 78$ per cent.; in sixty-six coals frow the northern half, $5 \cdot 120$; in all, from both regions, 4.891 ; or, omitting ten, having more than ten per cent. of ash, the average is 4"8. In eleven Ohio cannels, the average amount of ash was 12.827. The moisture in the Ohio coals, according to the analyses of Wormley, varies from 110 to $9 \cdot 10$ per cent. of the coal.

Mineral cosl oceurs in extensive beds or layers, interstratifed wih different rock strata. The associate rocks aro usualiy clay shales (or slaty beds) and sandstones; and the sandstones are occasionally coarse frit rocks or conglomerates. There are sometimes als, beds of limestone alternating with the other deposits.

Coal beds vary in thickness from a fraction of an inch to 40 foet. The thickness of a leed may increase or diminish much in the course of a few miles, or the coal may become too shaly to work.

The areas of the "coal-measures" of the Carboniferous cra, in the United States, are as follows:

1. A small area in Rhode Island, continued northward into Massachusetts.
2. A large area in Nova Scotia and New Brunswick, stretching eastward and westward from the head of the Bay of Fundy.
These two areas are now separated ; but it is probable that they ware once united along the region, now submerged, of the Bay of Fundy and Massachusetts Bay.
3. The Alleghany Region, which commences at the north on the southern borders of New York, and stretches southwestward across P'ennsylvania, West Virginia, and Tennessee to Alabama, and westward over part of Eastern Ohio, Kentucky, Tennessee, and a small fortion of Mississippi. To the north, the, (incinnati "uphift," or the Silurian area extending from Lake Erie over Cineinnati to Tennessee, forms the western boundary.
4. The Michigan eonl area, an isolated area wholly confined withia the lower peninsula of Michigan.
5. The Eastern Interior area, covering nearly two-thirds of Illinois, and parts of lndiana and Kentucky.
(i. The Western Interior area, rovering a large pat of Missouri, and extending north into Iowa, and south, with interruptions, through Arkansas into Tevas and west into Kansas and Nebraska.

The Illinois and Misouri areas are connected now only through the underlying Subcarhomiferous rocks of the age ; but it is probable that formerly fhe coal tields stretehed across the channel of the Mississippi, and that the present soparation is due to erosion along the valley. Rocks of the ('arboniferous period extend over large portions of the Rocky Monatain area, but they are mostly limestones, and are barren of coml.

The extent of the conl-bearing area of these Carboniferous regions is approsimately as follows:

| Rhode Island | 500 square n |
| :---: | :---: |
| Alleghany area | 59,000 square milい. |
| Michigan ares | 6,700 squart mile |
| Illinois, Indiana, West Kentucky | 47,000 square miles. |
| Missouri, Jowa, Kansas, Arkansas, Texas | "s,000 square mil |
| Nova Seotia and New Brunswick | 15,000 square mile |

The whole area in the United States is over 190,001 square miles, and in North America about 208,000 Of the 190,000 square miles, perhaps 120,000 have workable beds of coal.

Anthracite is the coal of Rhode Island, and of the areas in Central Penusylvania, from the Pottsville or Schuylkill coal field to the Lackawanna field, while the coal of Pittsburg, and of all the great soalfields of the Interior basin, is bithminoms, excepting a small area in Arkansas. Anthracite belongs especially to regions of upturued rocks, and bituminous coal to those where the beds are little disturbed. In the area between the anthracite region of Central Penasylvania and the bituminous of Western, and farther soa'b, the coal is semibituminous, as in 13road Top, Pemnsylvania, and the (Gumberland coal field in Western Maryland, the volatile matters yielded by it being 15
to 20 per cent. The more western parts of the anthracite coal fields afford the free-burning anthracite, or semi-anthracite, as at Trevorton, Shamokin, and Birch (reek.

The coal-formation of the Carboniferous age in Turope has great thickness of rocks and coal in Great Britain, much less in Spain, France, and (kermany, and a large surface, with little thickness of conl, in Russia It exists, also, and includes workable coal-heds, in China, and also in India and Australia; but part of the formation in these latter regions may prove to be Permian. No coal of this era has yet been found in South America. Africa, or Asiatic Russia. The projoptom of conl beds to area in different parts of Europe has been stated as follows: in France, 1-100th of the surface ; in Spain, 1-50th; in Belgium, 1-20th; in Great Britain, 1-10th. But, while the coal area in Great Britain is about, 12,000 square miles, that of Spain is 4,000 , that of France abont 2,000 , and that of Belgium $i 18$.

Mineral coal of later age than the true Carboniferous era occurs in various parts of the world. I'riassic or Jurascic coal, of the bituminous varioty, oceurs in thiek workable beds in the vicinity of Richmond, Virginia, and also in the leep River amd lom River regions in North Carolina; and it constitutes very valuable and extemive heds also in India. In England, at Brorn in Sutherhandshime, thero is a bed of Jurassic coal Coal of the Cretaceous aml Tertiary eras (enstitutes important heds in various parts of the liochy Mountain region, in the vicinity of the Pacific Railroad and res where. Some of the prominent localities are : In Citah, at Evanston and Coalville (in the valley of Weber River), ete; in Wyominge, at Carbon, 140 miles from (herenne ; at Ilallxille.' 1t: miles farther west ; at Black Butte Nitation, on Bitter (reek; on lear River, ete.; in the Vintah Basin, near Brush Creek, $f$ miks from Green hiver; in colorado, at Golden (ity, 15 miles west of Denter, on Ralston Crow, Coal (reek, S. Bonlder' (reerk and elsowhere; jn New Mexieo, at the Old Placer Mines in the San Lazaro Monutains, ete. The coal is of the bituminous or semithituminous kind, related to brown coal, and is often improperly called lignite. That of Bunston (where the bed is 26 foe thick) uforded Prof. P. Frazier, Jr, 3 i- .ind per cent. of volatile substances, 5 - 8 of water, $7-8$ of ash, and 49 -in of fixed carlon. At the Old Pacer Mines, New Mexico, there is anthracite, acording to I Dr, 1. Ledonte, affording 88 to 91 per ent, of fixed carbon; specimens from there, antyzed by Frazior, were semibituminons, affording fis-70 per exte of fixed carbon, ${ }^{2} 0$ per ernt. of volathle substances, and about $i$ per cent. of water. The region of the Old Placer Mines is one of upturned and altored rocks, like the anthracite reqion of Pennsylvania. Other similar beds occur toward the Pacific coast, the most valuable of them in Washington Territory, Seatlle and Bellingham: Bay, and on Vancouver and adjacent islands in British Columbia.

## I. CATALOOUE OF AMERICAN LOCALI. TIES OF MINERALS.

Trre following catalogue of American localition of minerals is introdueed as a Supplement to the Descriptions of Minerals. Its object is to aid the mineralogical tonrist in selecting his routes and arranging the plan of his jourmeys. Only important localities, affording cabinet sjecimens, are in gencral included; and the mames of those minerals ankich are obtainable in good specimerns are distinguished by italirs. When a name is not italicized the mineral occurs only sparingly or of poor quality. When the sperimens to be procured are remarkably good, an exclamation mark (!) is added, or two of those marks (! ) when the specimens are quite unique.

[^4]Greenwood.-Traphite, black manmanese, beryl! arsenopyrite, cassiterite, mica, rose quartz, garnet, corundum, albite, zircon, molybdenite, magnetite, copperas.

Herron.-Cassiterite, arsenopyrite, idocrase, lupidolite, hebronite, rubellite! indicolite, green tourmuline, wica, beryl, "qutite, albite, childrenite, roolecite.

Jewemalsland. -Pyrite.
Katamdin lnon Works.-Bog-iron ore, pyrite, magnetite, quartz.
Litciriels. - Sudalite, cancrinite, elaolitc, zircon, spodumene, mus. covite, pyrrhotite.

Lebec Lean Mines.-Galenite, chalcopyrite, blende.
Machasport.-.Jarper, epidote, laumontite.
Madawaska Settlements.-Vivianite.
Minot.--Beryl, smoky quartz.
Monmouth.-Actinolite, apatite, elcoliti, zircon, staurolite, plumose moca, beryl, ratile.

Mt. Abraham. - Andalusite, staurolite.
Norway.-Cherysoluryl! molybdenite, beryl, rose quartz, orthocitas', cinnamon garnet.

Orr's Island.-Steatite, garnet, andalusite.
Oxford--Garuct, beryl, apatite, wad, zircon, musenvite, orthoclase.
Paris.-Green! red! luack, and blue tontrmaline! mica! lepidoltte! feldspar, ablite, quertz crystals! rose quartz, cassiterite, amblygonite, zircon, brookite, heryl, mmoky quartz, spotumene, cookeite, leucopyrite
 sapolite, galenite, blende, chalcopyrite.

Peru.-Mrystallized pyritc.
Phippshetra. - Yellon garnet! manganesian gurnt. of suriutute, pargrsite, wrimite, laumontite! chabazite, an ore of cerium?

Polans.--Vesuvianite, smoky quartz, cinnamon garnet.
Pomtland.-Prelhite, actinolite, garnet, epidote, amethyst, calcite.
Pownal.-Islack tourmaline, feldspar, scajolite, pyrite, actinolite, apatite, rose quartz.

Paymond.-Magnctite, scapolite, pyrorenc, lepilotite, tremetite, hornblende. epidote, orthoclase, ycllow garnft, pyrite, vesuvianite.

Rockland. - Mematite, tremolite, quartz, wad, telf.
RUMFORD.-- Fellowo garnet, vesuviauite, pyraxenc, apatite, scapolite.
Rutland.-Allanite.
Sanify Rivere.-Auriferous sand.
Sanford, York Co.- Vtsuciunitc! albite, calcite, molybdenite, (pidote, black tourmaline, labradorite.

Searsmont. - Andalusitc, tourmaline.
Sorth lberwick.-Macle.
Streaked Mountann.-Beryl! black tourmaline, mixa, garart.
Thomaston. - Calcite, tremoolite, hornblende, sphene, arsenical iron (Owl's Mrad), black manganese (Dodge's Mountain), thomosonite, talc, blend', pyrite, galenite.

Topsinam.-Quartz, galenite, blende, tungstite? beryl, apatite, molybdenite, columbite.

Wares.-Axinite in boulder, alum, copperas.
Waterville.-Crystallized pyrite.

Windmam (near the bridge).-Staurohte, spodumene, garnct, beryl, amethyst, cyanite, tourmaline.

Winslow.-Cassiterite.
Winthrop.-- Staurolite, pyrite, hornblende, garnet, copperas.
Woodstock.-Graphite, hematite, prehnite, epidote, calcite.
York.-Bcry!, vivianite, oxide of manganese.

## NEW HAMPSIIIRE.

Acwontm.-Beryl!! mica! tourmaline, orthoclase, ainite, rose guartz, columbite! cyanite, autunite.

Alstead.-Mica!! allite, black tourmaline, molybdenite, andalusite, staurolite.

Amherst.- Tesuvianitr, ycllono garnct, pargasite, calcite, amethyst. bantlettr-Magnetite, hematite, smoky quartz.
Batm. - Galenite, chalcopyrite.
ismpord.-Tremolite, epidote, graphite, mica, tourmaline, alum, cuartz.

Bahows Faris.--Cyanite, staurolite, wavellite.
Bhistol. -Graphite.
(ampton...- Beryl!
(ANAAN.-(xold in pyrite, gannet.
Canaleston.- Etcurolite mucle, andalusite macle, log-iron ore, prehnite, cyanite.

Connish. - Stihnite, tetrahedrite, rutile in quartz! (rare), staurolite.
('mosmen - Yolite! chalcopyrite, pyrite, pyrrhotite, bleude.
Enfield. -Gold, galenite, staurolite, green quartz.
Franteston. - Smepstone, arsenopyrite, quartz crystals.
Eranconia.-IIoroblerde, strurolite! (judute! zoisite, hematite, mafuetite, black and rel manganesian garnets, arsenopyrite (danaite), chaleopyrite, molydenitr, pehnite, green quartz, malachite, azurite.
(infoni) (Gunstock M1:-Magnetic iron ore, native "lodestone."
Gimmantown.-Tremolite, epidote, muscovite, tourmaline, limonite, red and rellow quarts erestals.

Gosirn.-Graplitce, black tourmaline.
(inafton.- Mher! (extensively quarried at Glass IIill, 2 m . S. of Orange Summit), albite! blue, green, and yellow beryls! ( 1 m . S. of U . summit), tourmaline. garmets, triphylite, apatite, fluorite.

Gmantham - (iray, stourolit,!
Ghoton.-Arsenopyritn, blue beryl, muscovite crystals.
Hanover. - Garnct, blacle tourmaline, quarte, cyunite, lasraanritc, (pidote, anorthite.

Havermmar.-Garnet! arscnopyritr, hative arscnic, galenite, blende, pyrite, chalcopyrite, masnetite, marcasite, steatite.

Hirlsnoro' (Campbell's Mountain) -Graphite.
Hinsdale.-Rhodonite, black oxide of manganese, molybdenite, indicolite, black tourmaline.

Jackoon.-l)ras y quartz, tin ore, arsenopyrite, native arsenic, fluo. cite, apatite, maquetite, mo'ybdenite, wolframite, chalcopyrite.

Jafrizey (Monadnock Mt.)-Cyanite, limonite
Keene.- ('rraphite, soapsone, milky quartz, rose quartz.
Landafe. - Mofyderite, Iead and irun ores.

LEBANON.-Bog-irom ore arsenopyrite, galenite, magnetite, prite.
Lisbon.-Staurolite, black and red gurnets, matmetiti, hornblende. equidote, zoisite, hematite, arsenopyrite, galenite, wold, ankerite

Litrueton.-Ankerite, gold, bornite, chalcopyrite, malachite, me. naccanite, chlorite

Lyman.-Gold, arsenopyrite, ankerite, dolomite, galenite, pyritr, copper, pyrrhotite.

Lime.- (youte (N. W. part), black tourmatiqe, rutile, pyrite, chalcopyrite ( E of E . villarre), stibnitc, molyblenite, cassiterite.

Madinon.-Galrmite, be'nde, chalcopyrite, limonite.
Mermimiok.-Rutile! (in gneiss nodules in granite vein).
Middereown.-Rutilé.
Monadnock Mountain. - Andalusite, hornblende, garnet, graphite, tourmaline, orthoclase.

Moosmater Mt.-Tommulins.
Mommonborougif (Red Mill) - Momblende, bog ome, pyrite, tomemaline.

NewingTon-Gurnet, tourmaline
New LoNDon.-Beryl, molyhdenti', muscovite cryals.
Newront.-Molybdenite.
Orange.-Blue beryls! Orange Summit, chrysoberyl, micu (W. sido of mountain), apatite, galenite, limonite.

Orfond.-Bromen tourmaline (now obtained with difliculty), stratite, rutile, cyanite, brown iron ore, native copper, malachite, galenite, garnet, graphite, molybdenite, l'yrhutite, melaconite, chalcocite, mipiclulite.

Jendr m. - Statite.
Pienmont.--Muraceous iron, barite, green, white, and brown mica, apatite, tatanic iron.

Plymoutit.-Columbite, heryl
Rrcrmonn.-Iolite! rutile, steatite, prito, anthophyllite, talc.
Rye.- ('hiastolite.
Sindleback Mt.--Black tourmaline, garnet. spinel

SpRing fikld.-Beryls (very large, eight inches diamuter), mangunosian garncts! bluck tourmalime! in mica slate, albitı, mica.

Sullivan.-Tourmuline (black) in quartz, beryl.
Sumbey-Amethyst, calcite, galenite, limonite, touraaline.
Tamworth (near White Pond).-Galenite.
Unity (estate of James Neal). - C'opper and iron pyritcs, chlorophyllite, green miea, radiated actinolite, garnet, titanificrous iron ore, aredgnetite, tourmaline.

Walpole (near Bellows Falls).-Macle, staurolitr, mica, graphite.
Ware.-Graphite.
Warrens.-Cheldopyrite, menede, epinote, quartz, purite, tremoliti, galenite, rutile, tale, molybdenite, cinnamon stome! pyroxene, hornblende, bcryl, eyanite, tourmaline (massive) vesuvianite.

Waterville.-Labradorite, chrysolite.
Westmoreland (south part).-Molyblenite! apatite! hrie fildspar, bog menyanese (north villare), quartz, thuorite, chalcopyrite, molybdite.

White MTs. (Notch near the "Crawford House").-Green octahedral floorits, quartz crystals, black tourmaline, chiastolite, beryl, calcite, amethyst, amazon-stouc.

## Wilmot.-Beryl.

Wincmestrir.-l'yrolusite, rhodonite, rhodochrosite, psilomelane, magnetite, granular quartz, spodumene.

## VERMONT.

Addrson.-Iron send, pyrite.
ATmens.-- Ntcutite, rhomb sper, actinolite, garnet.
Balmmore.-S'rpentine, pyrite!
Behindere.-Sieatite, chlorite.
Benningiton.-Pyrolusite, brown iron ore, pipe clay, yellow ochre.
Berfinire.- - E'pidute, hematits, magnetite.
Betner.-Actimolite! tale, chlorite, octabedral iron, rutile, broun spur in stratitc.

Brandon.--Mraunite, pyrolusite, pasilmelene, limonite, lignite, kaolinite, statuary marble; graphite, chateopyrte.

Brattimborougn.--Black tourmaline in quarta, mica, zoisite. ratile, actinolite, scapolite, spodumene, roofing slate,

Bridfewatel - T'ale, dolomite, maymetite. steatite, chlorite, gold, native copper, blende, galenite, blue spinel, chaleopyrite.

Brrston--Rutilf, limonitr, manganese ores, magnetite.
Brookfinin.-- Arsemoprite. pyriti.
('abot--Giarnet, staurolite, bornblende. rellite.
Castheroy -- Remfing slate, jasper, manganese ores, cblorite.
Gavendmen.-- (inmet, surpaline, tule, steatite, tonrmalime, asbestus, tremolit.

Chester - Asbestux, feidspar, chhorite, quartz
Chittenden.-Psilomelane, pyrolusite, brown iron ore, lematite and mugnctite. galenite, iolite.

Colchesrem.--Brown iron ore, iron sand, jasper, alum.
Corinth.- Chatcopy rite (has been mined), pyrthotite, pyrite, rutile.
Conentry.-- Mhodenite.
(rafersbury.-Mica in concoutric balls, calcite, rutile.
Derny. - Mica (udamsite)
Dummerston.--lutile, roofing slate.
Fair haven.-Roofing slite, pryite.
Fletcher - Pyrite, magnetite, acicuhar tourmaline.
Gbafton- -The stoutite quarry referred to (irafton is properiy m Athens; quartz, actimolite.
Goumbend-Smpolite, rutile, roofing slate.
Hampord.- Calcite, qurit?! cyonit, quartz, tourmaline.
Irasbukg.-Thodonite: prillomelam.
Jay.- Uhromitc. scrpentinc, amianthus, dolomite.
howeds.-- licrosmine, amianthus, serpentine, tale, chlorite.
Mamboro'-- Rhomb spar, statite, gurnct, maynctitc, chlorite.
Mindifbery.-ZZircon.
Minnesex.-Rutile! (exhansted).
Monkrown - P'yrolusite, brown iron ore, pipe clay, feldspar.
Moretown.-Smuky quartz! st, atite, tale, wad, rutile, serpentine.
Mormetown--Galenite.
Mount Holls.-Asberstus, chlorite.
New Fane - Chlassy aud asbrstiform actinolite, steatite, groen quartz
(called chrysoprase at the locality), chalcedony, drusy quartz, garnct, chromic and titanic iron, rhomb spar, serpentine, rutile.

Norwich.-Actinulitc, foldspar, brown spar, in tale, cyanite, zoisite, chalcopyrite, pyrite.
Prtssfonn.-Branen iron ore, manganese ores, statuary marble!
Plymoctit.-Siderite, magnotite hematite, gold, galenite.
Plimpron--Massive homblende.
Putney.-Fluorite, limonite, rutile, and zoisite, in boulders, stau. rolite.

Reading.-Glassy artinolite in tale.
Readsbono'-Glassy actinulite, steutite, hematite.
Ripton.--Brown iron ore, angite in boulders, octahedral pyrite.
Rochester. - Rutile, hematite cryst., maynetite in chlorite slate.
Rockingham (Bellows Falls).-(yanite, indicolite, feldspar, tourmaline, tluorite, calcite, prehnite, staurolite.

Roxbury.-Dolomitc, tale, serp.ntint, asbestus, quartz.
Ruthand - Magnesit, white murble, hematite, serpentine, pipe clay.
Salmbicte.- Brown irno ore.
Shamon.-Quartz erystals, cyanite.
Snoreham. - Pyritc, hack marble, calcite.
Shrewsberx.-Magnetite and chaleopyrite.
Stimling.- (Thalropyrite, tale, serpentine.
Stockbidide.-Arsenopyrite, magnetite.
Strafforid.-Magnetite and chalcopyrite (has been worked), native copper, hornblende, copperas.
Thetrord.-Blende, galenite, cyarite. chrysolite in basalt, pyrrhotite, fcldspar, ronfing slate, steatite, garnet.

Townsmend.-Actinolite, hack mica, talc, steatite, feldspar.
Tros.-Magnctite, talc, serpentine, picrosmine, amianthas, steatite, one mile southeast of village of South Troy, on the farm of Mr. Pieree, cast side of Missisen, chronite, zaratite.

Versimbe. - Pyrite, chalcopyrite, tourmaline, arsenopyrite, quartz.
W'ansmoro'-Zaisitc, tourmaline, tremolite, hematite.
Whrman.-Actinolite, magnetite, wad, serpentime.
Waterbchy.-Arsenopryite, chalcopyrite, rutile, quartz, serpentine.

Watervine.--Steatite, artinolite, tale.
Weamersfield.-Stcutile, hematit', pyrite, tremolite.
Welis' Rivert-Graphite.
Westrield.- Stratite, chromite. serpentine.
Westminster.-Zoisite in boulders.
Windmam.-(ilassy actinolite, stcutite, garuct, serpentine.
Woonbury.-Massive pyrite.
WOoDstock.-Quurtz crystuls, garnet, zoisite.

## Massacildsetts.

Arforn-Galenite, pyrite.
AthoL.-Allanite , fibrolite (?), epidute! babingtonite?
Atbiens-Maromitc.
Barre.--Iutile! mica, pyrite, beryl, feldspar, garnct.
Great Barrington.-Tremolite.
Bedford,-Gitrnet.

Relcherton-Allanite.
Bernardston.-Magnetite.
Beverly.-Columbite, green feldspar, cassiterite.
Blanford.-Serpentine, anthophyllite, actinolite! chromite, cyanite, rose quartz in boulders.

Bolton.- - Secporlite! petalite, sphene, pyrorene, nuttalite, diopside, boltonitt, apatite, magnesite, rhomb spar, allanite, yitrocerite! spinel.

Boxbonougm.-swopolite, spinel, garnet, augite, actinolite, apatite.
Bmiditon.-Asbestus.
Brimpielid (road leading to Warren).-Tolite, alularia, molybdenite, mica, garnet.

Carlisle.-Tourmaline garnet! srapolite, actinolite.
Charlestown--Prchuite, luumontite, stilbite, chabazite, quartz crystals, melanolite.
Cimelmaford.-Stupolite (chelmsfordite), chondrodite, blue spinil, amimnthus! rose quartz.
 apatite, magnetite, chromite, stilbte, heulandite, analcios and chabazate. At the Emery Mine, Chester Factories.-Cormadinm, margavitr, dicrspope, epidste, corundophilite, chloritoid, tourmaline, monac canitc! rutile, liotite, indianite? andesite? cyomite, amesite.

Chesterfiend.-IMue, grecn, and red tominaline, cleavelanditc (allisite), lepidolite. smoki!y qurrta, mirrolite, sporlumone, cyanite, apatite, rase beryl, girnet, quartz crystuls, stanrolitc, cassitorite, columbite, zoisite, urauite, browite (eumanite), scheelite, anthophyllite, bornite.
Conwar,-Pyrilusite, fluorite, zoisite, rutile!! native alum, galenite.

Cemmingron.-Rhodonite! cummingtonite (hornhlende), marcasite, gurnet.

Deerfiend.-Chabazite, heulandite, stilbite, amethyst, carnelian, chalcedony, atgite.

Fitcinuma (Pearl Hill).--Beryl, strutrolite! garnets, molybdenite.

Frankin.-Amethyst.
Gosine -Miet. white, spondumene! wue and green tomermatine, $b_{c}$ 'gl, zuisitc, smoky quarta, columbite, tiu ore, galenite, beryl (goshonite, cymatolite.
(Gremifmen (in sandstone quarry, half mile cast of village).-Allophane, white and gremi-h.
hatpiend.-Barike, galenite, blende, chalcopyrite.
Mawney.-Micgecous !rin, massive pyrite, magnetite, zoisite.
heath- - 'yrite, zoisitc.
Hinsmale.- Brown iron ore, apatite, zoisite.
Mribbaimston.-Messief pyrite.
Huntinaton (name changiel from Norwich).-Apatite! hack tourmuline, beryl, spolumene! triphyliti (altered), blendr, quartz crystals, cassiterite.
lancaster_-Cymenite, chiastolite! apatite, staurolite, pinite, andar lusite.

Lee_-Tr molite! sphene! (east part).
Levenett.-Barite, gralenite, blende, chalcopyrnte.
Lexmen.--Zuisite, rutilc.
Littiefield.-Sidinel, scapolite,

Linnffied.-Magnesite on serpentine.
Mendon.-Mica! chlorite.
Midnlefield.-Gilassy uctinolite, rhomb spar, steatite. scrpentine, felddyerr, drusy quartz, apatite, zoisite, nacrite, chalcedony, talc! deweylite.

Milbury.- Temiculite.
New Brantriee. - Black tourmaline.
Newbery.-Sterpentim, chrysotile, cpidote, massive gurnct, siderite.

入ewhuryport.-- Crpontine, nemalite, uranite.-Argentiferous galenite, tetrahedrite, chatcopyrite, pyrargyrite, etc.

Northfiedd.-Gomblit', fitrolite, syanite.
Norwich. -- See Mratinaton.
Palmer (Three Rivers).--Hiddspor, calcite.
P'eleam.-Ashostus, serpentine. quertz crystals, beryl, molyddenite, grean harustome, epidote, anuethyst, cormondum, vermiculite (pelhamite).

Plasinfield.- Cumamingtonite, pyrolusite, rholomite.
Rucumond - Bronn" iron ore, gilhsite! allaphatm.
Roekport.- Dentalite, cry"phyllite, annite, cyptolite (altered zircon), gro en and whit, orthorltust, ferrusonite.

Rowe.-Epidote, take.
Soctu Rovalston.-Beryl!! (now obtained with great difficulty), miea!! fildspar! allanite. Four miles beyond ofd loe, on farm of Solmon lleyworel, miru! beryl! fildsper! menacernite.

Russel--Schiller spar (diallage ?), micu, serpentine, beryl, galenite, chaleoprite.

Salem.-In a boulder, cancrinite, sodalite, cleolite.
Shefriend. -Ashestus, pyrite, native alum, pyrolusite, rutile.
Sifmberne-Ratile.
Sifutesmery (east of Lecke's Pond).-Molydernite.
Socthampron -Golenite, cerussite, anglesite, onlffnite, fluorite, barite, prite, chalcopyrite, bleade, phosgenite, pyromurphite, stolzite, chas sucolla.
sterlixa-- spudumene, cheastulite, siderite, arsenopyrite, blende, galmite, chalcopyrite, pyrite, sterliagite (damourite).

Stoneham.-Nephite.

Swampacor.- Orthite, feldspar.
Tacnton (one mile south).-1’aracolumbite (titanic irom).
'T'urner's Falls (Comn. River)-Chalcopyrite, prehnite, chlorite, siderite, malachite.

Tymingham.-Pyroxane, scapolite.
Uxbridefe.-- -ialenite.
Warwick-Mhessice gernct, rediatcd black tommalini, mannctite, beryl, epidote.

Wasiington.-Griphite.
Westrield.--Schiller spar (diallage), serpentine, steatite, cyanite, scapolite, actinolit:.
Westrond.-Andahusit!!
West Hampton.-Galenite, argentine, pscudomorphous quartz.
West Springfield.-Prohnitc, ankerite, satin spar, celestite.
West Stockbridede.- Limonite, fibrous pyrolusite, siderite.
Whately. - Native copper, galenite.

Winliamsberf.-Zoivite, pseudnmorphous quartz, apatite, roce and smoky quartz, galenite, pyrolusite, chalcopyrite.

Williamstown.-..Cryst. quartz.
Windsor.-Zoisite, actinolite, rutile!
Worcester.- Arsenopyrite, idocrase, pyroxene, garnet, amianthus, bucholzite, siderite, galenite.

Wortmington.--'yanite.
Zoar.-Bitter spar, tale.

## RIIODE ISLAND.

Bristol.-- 1 methyst.
Coventry.-. Micu, tourmaline.
('RANn'Ton.-Actimolite in tale, graphite, cranite, mica, molanterite,
('umbmbland.--Mingumese, epilute, actimolite', sarnet, htaniferous iron, magnetite, red hematite, chalcopyrite, bornite, malachite, azurite, caleite, apatite, foldspar, zoisite, mica, quartz crystals, ilvaite.

Diamond Mml. - (quartz crystals, hematite.
FomTER-- 'y/mite, hematite.
Glortew
Jomnston.- Tale, brown spar, calcite, warmet, cpidote, pyrite, hematite, murnetite, chalcopy rite, malachite, azurite.

Natic.--sef Wal:WICK.
Newport. - Siphentinc, guarta crystals.
PoRtsuouth.-. Intherfite, qraphite, ashestus, pyrite, chaleopyrite.
 tine (bowenite), Emmolite, asbectus, quartz, maguetic iron in chlorite sinte, tuld! wetahedrite, feldspar. beryl

Valmey Fims. (iraphite, jeyrite, hematite.
Wapwick (Natic village).-Masonite, garuet, graphite.
Wenteris.-Menarcanite.
Wuonsocker --. janite.

## CONNECTICUT

Berlin.--Barite, datolite, blende, quartz erystals.
Bolqon.--Ntaurolite, chalenperite.
Bradheyvinhe (Litehfield)--Lanmontite.
Bmerol.--(huteocite, chalsoppritt', barite, burmete, allophane, pyromorphite, calite', malachite, galenite, quartz.

Bhookfimot--Galenite, calamine, Memede, spodumene, pyrrhotite.
('anidn.-T'remolte and white augite! in dolomite, canaanitemassive pyroxene).
(Hatmam.-Arsenopyrite, smaltite, cloanthite (chathamite), seorodite, niecolite, beryf, erythrite.
('ubsmme.-Baritc!' rhalcoritr, Iornitr', malachitr, kaolin, natrolite, prehnite, chalazite, datolite.

Chester - sillimanitr! zircon, epidote.
Connwali.. - (iruphitr, pyroxeme, actimolite, sple'me, scapolite.
Danbury.--Denburite, oligorlast, moonstont', brown tourmaline, orthoclase, pyroxene, parathorite.

Farmington.-Preluile, chabazite, agato, native copper; in trap, diabantite.

Granby.-Green malachitc.
Greenwich. - Black tormanaine.
Haddam.-Chrysoberyl! beryl! epidote! tourmaline! foldspar, garnct! iolitc! oligoclase, chlorophyllite! automolite, magnctite, adularia, apatite, columbintc! (hermannolite), zircon (calyptolite), mica, pyrite, marcasite, molyddenite, allanite, bismuth ochre, bismutite.

Hadlyme. - Chabazite and stilbite in gneiss with epidote and garnet.

Hartford.-Datolite (Rocky Hill quarry).
Kent.--Limonite, pyrolusite.
Lrterfield.-('yanite' with corundum, apatite, and andalusite, menaccanite (washingtonite), chalcopyrite, diaspore, niccoliferous pyrrhotite, margarodite.

LymE.- Garnet, sunstone.
Middlefield Falls.-Datolite, chlorite, etc., in amyerdaloid.
Middletown.-Mica, lepidolite with green and red tourmaline, atbite, feldspar, columbite! prchuitc, garnet (sometimes octahedral), buryl, topaz, uranite, apatite, pitchblende ; at lead mine, galemite, chalcopyrite, blende, quartz, calcite, fluorite, pyrite sometimes capillary.

Milford.-Sahiite, pyroxene, asbestus, zoisite, verd-antique, marble, pyrite.

New Haven.-Serpentine, sahlite, stilbite, prehnite, chabazite, laumontite, gmelinite, apophyllite, topazolite.

Newtown - -'yanite', diespore, rutile', damourite, cinnabar.
Nomwath.-Nillimanitr, momazite!'iolite, corundum, feldspar.
Oxford (near Humphreysville). - Cyanite, chaleopyrite.
Portland --Orthoclase, albute, muscovite, biotite, beryl, tourmaline, columbite, apatits.

Plymouth.--(ialenite, feulandite, fluorite, elloryphyllete! garnet.
Redodng (near the line of Danbury).-Pyroxene, garnet. Near Branchville R. R. depot: Albite, microrline, hroronite, spodumene! cymatolite, dammorit, eosphorite, triploidite, reddingite, dickinsonite, lithiophilite, rhodrehosite, fairfieldite, apatite, microlite, columbite, garnet, pyrite, tourmaline, staurolie, wraninite, torbernite, autuaite, vivianitr.

Roaring Brook (Cheshire).-Datolite! calrite, prehnite, saponite.
Roxbury. - Siderite, blende, myrite!! gatcnite, quartz, chalcopryite, arsenopyrite, limonite.

Salisbcirx.-Limonite, pyrolusitc, triplite, turgite.
Saybrook. - Molybdenite, stilbite, plumbago.
Sexmoun.-Native bismuth, arsenopyrite, pyrite.
Simsibury.-Copper glance, green mulachite.
Soummuny.-Rose quartz, laumontite, prehnite, calcite, barite.
Souturngton.-Barite, datolite, asteriated quarta crystals.
stafford. - Massive pyrites. alum, copperas.
Stonington.--Stilbite and chabraite on greiss.
Tariffvilee. - Datolite.
Thatchersvinle (near Bridgeport).-Stilbite on gneiss, babingtonite?

Tolland.-Staurolite, massive pyrites.
Trumbull ad Monroe.- (ihlorophane, topaz, beryl, diaspore, pyrrhotite, pyrite, niccolite, scheolite, wolframite (pseudomorph of scheelite), rutile, native bismuth, tungstic acid, sidorite, arsenopyrite,
argentiferous galenite, blende, scapolite, tourmaline, garnet, albite, augite, graphic tellurium (\%), margurodite.

Wasimggon. - Tripolite. menuccanite! (washingtonite of Shepard), rhodochrosite, natrolite, andalusitc (New Preston), cyanite.

Watentown, near the Naugatuck.-White sahlite, monazite.
West Farms.-Asbestus.
Wimbimante.-Topaz, monazite, ripidolite.
Wincmester and Wirton.-Asbestus, garnet.

## NEW YORK.

ALBANY CO.--BetmLemem.-Calcite, stalactite, stalagnite, calcareous sinter, snowy gypsum.

Coeyman's Landing.--Gypsum, epsom sult, quetz crystals at Crystal Mill, three miles south of Allany.

Gumbermand.-Petroleum, anthracite, and calcite, on the banks of Norman's Kill, two miles south of Alhany.

Watervinet.- (euartz crystals, fellow drusy quartz.
ALLEGHANY CO.-CvBa.-Calcareous tufa, petroleam, 3! miles from the village.

CATTARAGGUS CO.-Freedom. - Pitrolemm.
CAYC(xA CO.-Avmen.-Celestite, calcite, fluor par, epsomite.
springrokt. - At 'Thompsom's plaster beds, sulphur! selente.
SphingVIme. - Nidrogen springs.


l.AONA.--1' ${ }^{\prime}$ (1roleum.

Clinton Co.-Arnold Inon Mine.-Mrgnetite, epidote, molybdenite.

Finch One Ben.-Calcitc, grem and purple fluor.
COLUMBIA (O.-ADs'mentrz. - Eiththy mutgancac, wulfenite, chalcocite; Livingston lead mine, galenite.
('matmam.- (quartc, prote in cubic crystals in slate (IMillsdale).
Canasn--Chaleocite, chalcopyrite.
llemon.--Epidote, selemitr!
New Lebanon. - Nitrogen springs, graphite, anthracite; at the Ancram lead mine, galenite, barite, blewhe, erulfinile (rare), chalcopyrite. calcareous tufa; near the city of Ifudson, ejsom salt, brown spar, mad.

DUTCLIESS CO.-Amenia.-Dolomite, limonitc, turgit:
Beekman. - Dolomiti.
Dover.-Dolomite, tremolite, garmit (Foss are bed), staurolite, limonite.

Fisminlı.--Dolomite; near Peckville, tale, asbestus, traphtiti, hornblende, angire, actinolite, hydrous anthophyllite, limonite.

Nontir East.- (halcocite, chalcopyrite, galenite, blende.
Rimnebebz.-Calcite, green feldepar, epidote, tourmaline.
Tnion Vale.-- At the Clowe mine, gibbsite, limenite.
ESSEX (O.-Armandma.-Kirby's graphite mine, graphite, pyroxene, serapolite, sphene.

CRown Point.- - Patite (rupyrehroite of Emmoms), hroun tourmalinc! in the apatite, chlorite, quartz crystals, pink and blue calcite,
pyrite; a short distanee south of J. C'. IIammond's house, garnet. stapolite, chalcopyrite, aventurine feldsper, zircon, magnetic iron (l'eru), epidote, mica.

Keene.--Scapolite.
Lewis. - Tabuler apar, eolophonite, garnet, Ialradoritr, Zorrublende, actinolite ; ten miles south of the village of heeseville, arsenopyrite.

Long Pond. - Apatite, garmat, pyroxeme, idocrase, cuccolite!! scapolitc, magnetite, blue calcitc.

McIntime. - ladradorite, garnet, magntitc.
Moniair, at Sandford Ore Bed.-Mramutite, apatite, cilanite! lanthanite, actinolite, and feldspar; at Fisher Ore Bed, magmetite, fellospar. quartz ; at Mall Ore Bed, or "New Ore Bed," matnctit, zircons ; on Mill brook, ralcite, pyroxene, horublende, abbite: in the town of Moriah, magnetite, black mica; Barton Hill Ore Bed, allili.

Newcomb.-Labradorite, feldspar, magnetite, hypersthene.
Port Heniry.-Ibroom tourmaline, mied, ruse guartz, serpentine, green and buck phrorche hornblende, cryst. pyrite, graphite, wollastonite, pyrrhotite, mollaria; phlogrgite! at Cheever Ore Bed, with magnetite and serpentine.

Romines Rock.---(iraphite, vollestomite, garnet, collophonite, foldsibur, adularia, pororene, sphene. coccolite.

Scmmon.--c'uldite, proxeme, chomedrodite.
Ticonderoca.-Graphite! pyroxthe, sahlite, sphene, black tourmaline, cacoxent? (Mt. Defiance).

Westron'r-Lahradorite, prehnite, magnctite.
Willsboro'- Willentonite, culophonite, garnet, green soccolite, bornblende.

ERIE CO - Fincotr's Mmxs.- Calcarems tufas.
FRANKLIN CO.- ('hateavgiy. - Nitrogen springs, calcareous tufas.

Malone.--Mressic miritr, magnetite.
GENESEE CO.- Arid springs containing sulphuric acinl.

Dhamond Milin- Quartz crystals.
HAMILTON (O-HGAG LAhE.-Blue calcite.
HERKIMER CO.-FADBLELD-Qurta crystals, fetid barito.
litule Falds.-Quat: reystots! barite, calcite, anthracite, pearl spar, smolly quartz; one mile suuth of Lattle Falls, calcite, brown - har, faldspar.

Minnmevilme -Quartz crystaly! calcite, brown and pearl spar, anthracite.

Newpont. -Quartz crystals.
Salisbory- - Quartar rystols! blende, galenite, pyite, chalcopyrite.
Stark.--Fibrous relestite, gypsum.
JEFFFRPSON (O.-ADAMs.-Fluor, calc iufa, barite.
Alexandma.-On the S. E. hank of Muscolonge Lake, fluorite (exhatusted), phlogopite, chalcopyrite, upatite ; on High lsland, in the St. Lawrence River, frddepar, tourmaline, hornblende, onthorlase, celestite.

ANTWERP.--Sterling iron mine, hematite, clealcodite, sid+rite, millroite, red homotite, crystallized quartz, yellomo afogonite, niccoliferous pyrite, quartz crystals, pyrite; ; at oxbew, rulrite! porous coralloidal heavy spar; near Vrooman's luke, calcife! vesuvianite, phlegopite! pyroxene, sphent, fluorite, pyrite, chalcopyrite; also fildspar, bug-iron
ore, scapolite (farm of Eggleson), serpentine, tourmaline (yellow, rare).
Brownsville.-Celestite in slender crystuls, calcite (four miles from Watertown)
Natural Bridge.-Gieserkite! stentite psculomorphous after pyroxene, apatite.
New Connecticut.-Sphene, broon phloyopite.
Omar.-Beryl, feldspar, hematite.
Philadelphia.-Guruets on ludian River, in the village.
pamefin. - Agaric mineral, cale tufa.
prenrepont - Tourmaline, sphene, scapolite, hornblende
Pidiar Ponnt. - Magssive barite (exhausted).
Therbsa. - F'uorite, caldite, hematite, humblende, quariz crysbill, scrpentine (associated with hematite), celestite, strontianite.

Wathrtown.-Tpemolite, agaric mincral, cale tula, celestite.
Whina.- One mile uorth of Natural Bridge, calcitc.
LEWIS CO.-- DinNa (localitics mostly near junction of crystalline and sedimentary rocks, and within two miles of Natural Bridge). stapholite! wollastonite, grcen corcolite, fildspurr, tremolite, pyron'the! sphene! ! mica, quartz crystinls, drusy quartz, "ryst. py rite, pyrrhotite, blue calcitc, serpentine, renssela rite, zircon, graphite, chlorite, hematite, bug-iron ore, iron sand, "putitc.

Grbaci--Magnctite, pyrite.
Lowvina- - (idment flumite, pyrite, galenite, blende, cale tufa.
Marminsburin --Wial, galenite, etc., but mine not mow opened, calcite
MONROE CO.--Rochester - Pearl spar, calcite, snowy gypsum, flume enlestite, galenite, bende, harite, harnstone.
MoNTGOMERY CO.-Palatine - Quertz reystals, drusy quartz, anthracite, hornstome, agate, garnet.

Root.--Druxy quartz, blende, barite, stalactite, stalagmite, gal'nite, pyrites.

NEW YORK CO.-Corlear's Hook.-Apatite, brown and yellnw feldśpar, sphene.

ILARLem--Fpidote, apophyllite, stilbite, tourmaline, vivianite, lamellar feldspar, mica.

Kingabridoe.-Tremolite pyroxene, mira, tourmaline, pyrite, rutile, dolomite.

New Yonk - Seppentinc. amianthus, actinolite, purapenc, hydrous anthophyllite, garnct, staurolite, molybdenite, graphite, chlorite, jasper, nerronitr, feldspar. In the excavations for the 4 th $\Delta$ venue tumel. 18 i5, harmotone, stilbite, chabazite, heulandite, etc

Niagara Co.-Lewtston.-Epsomite.
Locкровт.--Celestite, calcite, selenite, anhydrite. fluorite, dolomite, ulende.

Niacara Falis.-Caleite, fluorite, blende, delomite.
ONEDDA CO.--Boonvine.-Caleite, vollestonite, cormelite.
(cinnton---Blende, lenticular argillacenus iron ore in rocks of the Clintongroup, strontianite, eelestite, the former evering the latter.

ONONDACA CO.-Cammbes.--Selenite and fibrous gypsum.
Cond Siring.--Axmite.
Manlius.--Gypsum and fluor.
Stracuse. - Scrpentine, colestite, selenite, barite.

ORANGE CO,-CORNWALl.-Zırcon, chondrodute, horrhende, spinel, massive jeldspar, filrous cpidote, hudsonite, meuaccanite, serpentene, cuccolite.

Deer Park.-Cryst. pyrite, galenite.
Monnoe.--Mica! sphelu! garnct, colophonite, cpidote, chondrodite, allanite, bucholzite, brown spar, spincl, hornblende, tale, menaccunite, pyrrhotitc, pyrite, chromite, graphute, rastolyte, morouolite.

At Wilks and O'Neill Mine in Monroe.-Araronite, magnetite, dimagnetite (pseud.?), jenkinsite, asbcstus, serpentine, mica, hortonolitc.

At 'Two Ponds in Monroe.-Pyroxene! choudrodite, hornllende, scapolite! zirron, sphene, apatite.

At Greenwood Furnace in Monroe.-Choudrodite, pyroxcue! mica, hornblende, spinel, scapolite, biotite! menaccanite.

At Forest of Dean.-Pyroxcue, spincl, zircon, scapolite, hornblende.

Town of Warwick, Warwick Village.-Spinel! zircon, seppentime! brown spar, pinoxene! hornble'ude! pseudomorphous stettite, fildspar! (Rock Mill), menaccanite, clintonitt, tourmaline (R. H.), putile, sphech, molybdenite, arsenopyrite, marcasite, prrite, yellow iron sinter, quartz, jasper, mica, coccolite.

Amity.-Apind! garnet, seapolide, hormhende, vesurianite, cpidote! clintonite! magnetite, tourmaline, warwickite, apatits., chondrodate, talc! pyroxene! ratile, menaccanite, zircon, corundurn, fildsput, sphenc, calcite, serpentine, schiller spar (?), silvery mica.

EDENVILLE.-Apatitc, chondrodite! hair-bronrii horublende! tremolite, spinel, tourmaline', voarviclite, pyroxene, spfucue, mica, foldspur, arsenopyrite, orpiment, rutili, menaccanite, scorodite, chalcopyrite, lcucopyrite (or lollingite), allanite.

West loint.- F'ldspar, mira, scapolite, sphene, hornulende, allanite.
PUTNAM (O.-Mrewstha, Tilly Fostor Iron Mine.-Thondrodite! (also humite and clino-humite) crystals very rare, malynetite, dolomite, scrpentime, pseudomorphs, brucite. enstatite, ripidolite, biotite, actinolite, aputite, pyrrhotite, fluorite, albite, epidote, sphene.

ANTHoNy's Nose, at top, prite, pyrrhotite, pyroxene, hornblende, magnctite.
('armel (Brown's quarry).-Anthophyllite, schiller spar (?), orpiment, ursmoprrite, epidote.

Cold Spring.-Chubazite, mica, sphene, epidote.
Patterson. - White pyroat ne! calcite, asbestes, tremolite, dolomite, massive pyrite.

Phillipstown.-Tremolite, amianthus, serpentine, sphene, diopside, green cocrelite, horublende. scapolute, stilbite, mica, laumontite, gurhofite, calcite, magnetite, chromite.

Pimlimps Ore Bed.-Hyalite, actinolite, massine pyrite.
RENSSELAER CO.--Hoosic.-Nitrogen springs.
lansingburtif.- Epanmite, quartz rrystals, pyrite.
Trox.-Quartz crystals. pyrite, selenite.
RICHMONI) (O.-lROSsville.-Lignite, cryst. pyrite.
Quarantine.-Ashestus, amiantlus, aragonite, dolomite, fushofite. brucite, serpentinc, tair, magnesite.

ROCKLANI) (O.-C'AlinWElL.-Calrite.
Grassy Point.-Serpentine, actinolite.

## Haverstrawi.-Hornulende, barite.

Ladentown. Zircon, malachite, cuprite.
Piermont.-Datolite, stilbite, apophyllite, stellite, prehnite, thomsonite, calcite, chabazite.

ST. LAWRENCE CO.-CANTon.-Massive pyrite, calcite, brown tourmaline, sphene, serpentine, talc, renssclaerite', pyroxene, hematite, chaleopyrite.
I) graphite, pyroacone, quartz (spongy), serpentine.

EDWARDs.- Brown and silvery mica! scapolite, apatite, quartz crystals, actmolite, tremolite! hematite, serpentine, magnetite.

Fine.-Black mica, hornblende.
Fowner.-Burite, quartz crystals! hematite, blende, galenite, tremolite, chalcedony, bog ore, satin spar (assoc. with serpentive), pyrite, chalcopyrite, actinolite, rensselacaite (near Somerville).

Gouvernsur.- (ialcite! serpentine! hornblende! scapolite! arlhoclase, torumaline! idocrase (one mile south of (i.), pyroxene, malucolite, apatite, renssclacrite, serpentine, sphene, fluorite, harite (farm of Jadge Dodgen, black mica, phlogopite, tremolitc! asbostus, hematite, graphite, vesuvianite (ncar Somerville in serpentine), spind, houghite, scapolite, phenopite, dolomite; three-quarters of a mile west of Somerville, chondrodite, spinel; two miles north of Somerville, apatiti, pyrite, brown tournatinc!!

Hammund - Aputite! zircon! (farm of Mr. IIurdy!, orthocletse llosocase), purgasitc, baritr. pyrite, purple fluorite, dolomite.

Mrmmon - Guartz crystuls, hematite, siderite, pargasite, pyroxene, serpentine, tourmalino, bog-iron ore.

Macomb.-Blende, mica, galenite (on land of James Arerill), suhene.

Minerdi Point, Morristown.-Fluorite, blende, galenite, phllogo2ite ( ${ }^{2}$ 'ope's Mills), barite.

Oqdensburgif.-Labradorite.
1'Tt ARKN. - Satin spar, associated with serpentine
Potsinn - - Ilormblende! ; eight miles from Potsdam, on rond to Pierrepont, fildspar, tourmaline', black mica, hornhhende.

Rossie (Iron Mines).-Barite, hematite, coralloidal aragonite in mines near somerville, limonite, quartz (sometimes stalactitic at Y'arish Iron Minel, pyrite, pearl spar.

Rosnie Lead Mine.-Calcitc! galcuitc! pyrite, celcatite, chalcopyrite, hematite, cerussite, anglesite, octahudral flewr, black phlogupitc.

Elsewhere in Rossme - - 'alcit, barite, guartz crystals, chondrodite (near lellow Lake), fildspar! pargasite! apotite, fyromene, hornblende, sphene, zircon, mira, fluorite, serpentine, automolite, pearl spar, graphito.

Ressel.- I'argusite, spocular iron, quartz (dodec.), calcite, serjeutine, reusseluerite, magnetite.

SARATOGA CO.-GREENFWLDS-Chrysoberyl! gurnt! tourmaline! mira, feldspar, apatite, graphite, aragonite (in iron mines).

S(MOHARIE CO.-BALL's CAVE, and others.-Calcite, stalactites.
('arlisle.- Hibrous barite, cryst. and fibrous calcite.
Mididebury.--Asphaltic coal, calcite.
Sharon. - Calcareous tufa.
Sohomame.-F'ibrous celestite, strontianite! cryst. pyrite!

SENECA CO.-Canoga.-Nitrogen springs.
SUllivan Co.--Wurtzboro'-Galenite, blende, pyritc, chalcopyrite.

TOMPKINS CO.-Itmaca.-Calcareous tufa.
ULSTER CO. - Ellenville. - Galeniti, blende, chalcopyrite! quartz, lirookite.

Marbletown.-Pyrito.
WARREN CO.-Caldwell.-Masside feldspar.
Chestra.-P Pyrite, tourmaline, rutile, chalcopyrite.
Diamond Isie (Lake George).-Caleite, quartz erystals.
Gienn's Falls - Rhomb spar.
Jomnsbergif - - Fluorite! zircon! graphite, serpentine. pyrite.
WASHINGTON CO.-Fort Ann.-Gruphate, serpentine.
Granvilie.-Lamollar pyroxche, massive feldspar, epidote.
WAYNE CO.--Woncotr -- Barite.
Westrillester Co.-Anthony's Nose.-Apatite, pyrite, calcitc! in very large tabulur crystals, grouped, and sourtimes incrusted with druse quartz.

Darenport's Neck.-Girpentint, garnet, sphome.
Fastchester.-Blende, pyrite, chalcopyrite, dolomite.
Hastings - Tremolite, thite pyrovene
New Rochflle.-Serpentine', brucite, quartz, mica, tremolits, garnet, macressite.

Peekskill.-Mica, feldspar, hornblende, stilbite, sphene; three miles south, emery.

Rive.-S'rpentine, chlorite, hlack tourmaline, tremolite.
Sing Sing.-Pyrorene, tremolite, purite, beryl, azurite, green malachite, cerussite, pyromorphite, anglesite, vauquelinite, galenite, native silver, chalcoprrite.

West Fams.-Apatite, tremolite, garnet, stillite, heulandite, chabazite, epidote, sphene.

Yonkres.- Tremolite, apatite, calcite, analcite, pyrite, tcurmalinc.
Yonkrow -- Fibrolite, momuzit, magnetite.
WYOMING CU.-W yomine.-Rock salt.

## NEW JERSEY.

Andover Iron Mine (Sussex Co.)-Willemite, brown garnet
Allentown (Mommouth Co.)-Vivianite, dufrenitc.
Belliville. - Copper mines.
Bergen.-Callite! dufolite! pectolite! anolrite, apophyllite! gmelinite, prehnite, sphene, stillhite, natrolite, heulandite, laumontite, chormazite, pyrite, pseadomorphous steatite imitative of apophyllite, diabantite.
Brunswick.-Copper mincs: native copper, malachite, mountain $l_{\text {futher. }}$

Bryam.-(Chondrodite, spinel, at Roseville, cpidote.
'cantwell's Bridge (Newcastle Co.), three miles west.-Vivianite.

Danville (Jemmy Jump Ridge).-Graphite, chondrodite, augite, mica.

Fllmington.-Copper mines.

Frankfort.--Sierpentine.
Franklinn and Sterling (Sussex Co.)-Spincl! garmet! rhodonite! willonite! franklinite! zincite! dysluite! horublende, tremolitc, chorndrodite, uhite srapolite, black tourmaliue, epidote, mica, actinolite, augite, sahlite, coccolite, asbestus, jeffrsonite (augite), calamine, graphite, fluorite, beryl, galenite, serpcutine, honey-colored sphene, quartz, chalcedony, amethyst, zircon, molybdenite, vivianite, tephroite, rhodochrosite, aragonite, sussexite, chalcophanite, ropperite, culcozincite, vanuxemite, gahmite, hetarolite. Also alferitc in gran. limestono.

Franklin and Warwick Mts.-Pyrite.
Greenbrook.-Copper mines.
Giriagrown.-Copper mines.
IIsmbergit.- One mile worth, spintl! towrmalime, phlogopite, horiabbende, limonete, hematite

Hoboken -Serpentine (marmolite), bracite, memalite (or fibrous brucite), aragonite, dolomite.

Hunis Town.- 1 patite, pyrrhotite, magnetite.
Imlayrown.-- Vivianite.
Lockwood.-- (r'uphete, chondrodite, tale', augite, quartz, grect spinel.

Montuilme (Morris (\%.)-Serpentine. chergotile.
Mumbed IIbl (G)oucester Co.)-Viviunite lining belemnites and other fossils.

Newton, - Spimet, blue, pink, and white corundum, mi'd, vesuvianite, horublende, tourmalum, serpolite, rutile, pyrite, tale, calcite, barite, pseudomur hous stectite.

Patehnon.-Dididit:
Vernus.-Serpeutine, spinel, hydrotalcite.

## PENNSYLVANIA.*

ADAMS (O.- (iettrsburg.-Epidnte, fibrous and massive.
BERLS' ( $0 .-$ Morgantown.-At Jones's mines, one mile cast of Morgantown, malachite, native copper, cherysocolla, mut!ucttr, allsphane, prote, chalcopyrite, aragonite, apatite, dale, voncrite; two miles N. E. from Jones's mine, graphite, sphene ; at Steele's mine, one mile N. W. from N't. Mary's, Chester Co., magnctite, micaceous iron, coccolite, brown garnet.

Rendinat.-- Smoly quartz crystals, zireon, stillite, iron ore; near Pricetown, zirem, allanite, cpidote; at Eckhardt's Furnace, cellamete with zireon ; at Zion's Church, molybdeuite ; near Kutztown, in the Crystal Cave, stalactites; at Fritz Island, opophylliic, thomsonite, sherbazite, calcitr, azurite, malarhite, macratite, chalcopyrite, stibnite, prochlorite, precious serpentine.

BUCKS (O --Bu'kingham Township.--C'rystallized quartz; near New Hope, vesuvianite, epidote, barite.

Southampon.- Near the village of Feasterville, in the quarry of George Van Arsdale, araphite, pyromene, sahlite, cuccolite, spheme, green mica. calcite, wollastomite, glassy feldspar sometimes opalescent, phlogopite, blu quartz, garnet, zircon, pyrite, moroxite, scapolite.

[^5]New Bartans.-Dolomite, galenite. blende, malachite.
CHESTER CO.-Avondale.--Asbestus, tremolite, garnet, opal.
CARBON CO.--Summit Hml, in coal mines.--Kaolinite.
Binmingham Townsmir. - Amethyst, smoky quartr, serpentinc, beryl ; in Ab'm Darlington's lime quarry, calcite.

East Bradrord.--Near Buffington's bridge, on the Brandywine, green, bluc, and gray cyanite, the gray cyanite found loose in the soil, in crystals; on tho farms of Dr. Elwyn, Mrs. Foulke, Wm. Gibbons, and Saml. Entrikin, amethyst. At Strode's mill, nsbestns, magncsite, anthophyllite, epidote, arpuacrepitite, oligoclase, drusy quartz, collyritc? on O.borne's Hill, vad, mangatersian gurnet (massive), spheme schorl ; at Caleb Cope's lime quarry, fetid dolomite, nceronite, garnets, hue cyanite, yellow artinolite in talic; near tho Black Morse Inn, indurated thele, rutile; on Amos Davis's farm, orthite! massive, from a grain to lumps of one pound weight; near the paper-mill on the Brandywine, zircon, associated with titanitivous: iron in blue quartz.

West Bradford. -Near the vilhare of Marshalton, gren eyonite, rutile, scapolite, pyrite, staurolite; at the Chester Comnty Poor-honse limestone quarry, chestcrlite! in crystals implanted on dolomite, rutilc! in brilliant acicular crystals, which are finely terminated, calcite in scalenohedrons, zoisite, drmouritc? in radiated groups of crystals on dolomite, guartz crystals; on Smith \& McMullin's furm, cpidote
('manlestown.- P'yromorphite, erruwite, galenite, quartz.
Coventry.-Allanite, near Pughtown.
Sortif Corentry.--In Chrisman's limestono quarry, near Corentry village, augite, sphene, graphite, zircon in iron ore (about half a mile from the village).

East Fallonfield.-Soapstone.
East Gosmen.-Serjentine, ashostue, magnetite (lodestone), garnot

Lha -Menaccanite with museovite, chromite ; at Lewisville, black tourmoline.

West (dosmen.-On the Burrens, one mile north of West Chester, anianthus, serjentine, cellular quartz, jasper, chaleedony, drusy quartz, chlorite, marmolite, indarated talc, magnesite in radiated crystals on serpentine, hematite, asbestus: near R. Taylor's mill, chrmito in octahedral crystals, daccyliti, raliatod mumesitt, aragronite, sturorolite, garnet, asbestus, epidote; zrisiti on hornhlende at West Chester water-works (not accessible at present).

New Garden.- At Nivin's limestone quarry, brourn tourmaline, necronitc, scapolite, apatite, brown and green mica, rutile, "rogonite', fibrolite, Ruolinite, tremolite.

Kennett.--Actinolite, brown tourmaline, brown mica, equinte, tremolite, scapolito, aragonite; on $\mathrm{VIm}^{\text {. Cloud's farm, sunstome! ! cha- }}$ bazite, sphene. At Pearce's old mill, zoisite, quidole, sunstone; sunstone occurs in good specimens at various places in the range of hormblende rocks running through this township from N. E. to H. W.

Lower Oxfond.-Garnets, muite in cubic crystals.
London Grove-- Rutile, jasper, chalcedony (botryodal), larse and rough quartz crystals, epidote; on Wm. Jackson's farm, yrllion ant mack tourmalime, tremolite, rutile, green mira, apatite; at Pusey's quarry, ratile, trrmolite.

East Marimonocgif.-On the farm of Baileg \& Brother, ono milo
south of Unionville, bright yclon and nearly white tourmaline, chesterlite, albite, pyrite; near Marlborough meeting-house, epidote, serpentine, acicular black tourmaline in white quartz; zircon in small perfect crystals loose in the soil at Pusey's sawmill, two miles S. W. of Unionville.

Wert Marlborotgh.--Near Logan's quarry, staurolite, cyanite, yellow tourmaline, rutilo, garnets ; near loee Run village, hemutite, scapolite, tremolite, in R. Baily's limestone quarry, two and a half miles S. W. of Unionville, fibrous tremolite, cyanite, sapolite.

Newhin. - On the serpentino barrens, one and a half mile N. E. of Unionville, corundum! massive and crystallized, also in crystals in allite, often in hose crystals covered with a thin coating of steatite, spinel (hack), tale, picrolito, hrucite, green tourmaline with that pyramidal trminations in albite, "niomit' (rare, enphyllite, mica in hexagonal crystals, feldspher, beryl! in hexagonal crystals one of which weighs 51 lhs, pyite in cubic crystals, chromic iron, drusy quarta, green quartz, actinolite, emerylite', chloritold, diallage, oligoclaxe'; on dohnson Patterson's farm, massive corundum, titaniferous iron, clinurhlore, cincrylite, sometimes colored green by chrome, albite, orthoclasi, halloysite, margarite, garnets, liryll ; on J. Lesley's farm, cormadum, crystallized and in massive lumps one of which weighed 5,200 lhs.,
 transparent crystals in the cuphyllte, orthorlase; ; two miles N. of Unionville, mayputite in octahrdral crystals; one mile E. of Cuionville, lumatite; in lidwards's old limestone quarry, purple fluorite, rutile.
E.ser Nottinamiv.--. $1 s^{3}$ stus, chromite in crystals, hallite, beryl.

West Notringhav - it Sicott's chrome mine, chromite, folict, d tale, marmolite, serpentine, chate dony, rhodochrome; near Moro Phillips's chrome mine, "s'restus; at the magnesia quarry. deneylite, marmolite, magnesite, leclite, serpentine, chromite ; near Fremont l. O., corundum.

West Pheland.-In the iron mines near Chester Springs, gibusitc, sireon, turgite, fumutitr (stalartitical and in geodes), göthite.

Penn-(daruets, agalmatolite.
Penngbury.-On John (raig's farm, brown garnets, mira; on J. Dilworth's farm, near Fairville, musconcite! in the village of Fairville. sunstone; near Brinton's Ford, on the Brandywine, chendrodite, sphene, diopside, augitc, coccolite; at Mendenhall's oh limestono quarre, fi tid quirta, sunstone ; at Swain's quarry, orthoclace.
Pocopion.-On the farms of John Entrikin and Jos. B. Darlington, amethyst.

Stdsmury.-Rutide!! splendid geniculated crystals are foum lonse in the soil for scren miles along the valley, and particularly noar the village of Parkesburg, where they sometimes occur weighint one pound, doubly geniculated and of a deep red color; near Sadsbury village, amithyst, tourmaline, epidote, milk quarts.

Scheylifll,- In the railroad tunnel at Perenisvinee, dolomite? sometimes coated with pyrite, quartz erystals, yellow blende, brookite, coleite in hexagonal crystals enclosing pyrite; at the Wrieatley, Brookdale, and chemter Corsty liead Mines, one and a half mile S. of Phœnixville, pyromorphite! cerussite! gulerite, anglesite!! quartz crystals, chalcopyrite, barite, fluorite (white), stokitc, wulfchitc!
calamine, vanadinitc, blende! mimetite! descloizite, göthite, clırysocolla, native copper, malachite, azurite, limonite, calcite, sulplur, pyrite, melaconite, pscudomalachite, gersdorifite, chalcocite? covelite.

Thonnbury. - On Jos. H. Brinton's farm, museozite containing acicular crystals of tourmaline, rutile, titaniterons iron.

Tredyffrin.-Pyrite in cubic crystals loose in the soil.
UwChlan.-Massive blue quartz, graphite.
Waferen.-Mchenite, feldspar.
West Gosinen (one mile from West Chester) - ('hromite.
Whbistown.-Magnetite, chromite, actinolite, asbrestus.
What Town.-On the serjentine rocks, 3 miles s. of West Clester, rlinochlore! jeflimisite! mica, asbestus, actinolite, magnesite, tabe, titaniferons iron, magnetite and massive tourmaline.

Elst Wmitelanis.-Pyrite, in cubic crestals, guartz erystals.
West Whitheand.-St Gen. Trimble's iron mine (sontheast), statactitic hemetiti! wazellite!! in radiated stalactites, gibbsitu, caerulaolactile.

Warwick.-At the Elizaboth mine and Keim's old iron mine wijoining, one mile N . of Knauertown, aplome garnet! in brilliant dodecahedrons, flowforie, pyroxene, micacious hematite, pyrite in bright octahedral crystals in calcite, chrysocolla, chalcópyrite massiye and in single tetrahodral crystals, magnetite, fascirular hormblude! bomite, maluchite, browen garnet, calcite. byssolite! serpentine; near the villamo of St. Mary's, magnetite in dodecahedral crystals, milnite, fornct. actimoite in small radiated nodules; at the Hopewell iron mine, one mile N. W. of St. Mary's, magretibe in octahedral crystals.
('OLTMBLA (O.-At Wehb's mine, yellow blendé in calcite; near Dhomburer, cryst. magnetito

DAEPIfN G.-AEAR IIGmmerstown--Green garnets, cryst. smoky quevt: foldspar.
 rylite, staurolite, fibrolite, black tourmaline, metrgeriti, smonstone, asbosthes, anthophyllite, steatite; near 'Tyson', mill, garmet, staurolite; at Peter's milliam in the creek, purope garuet.

Brmmingmom. - Fibrolite, kuolin (abundant), crystals of rutile, amethyst ; at Bullock's old quarry, zirenn, Zucholzite, natrite, yellow crystallized quartz, foldspuer.

Blee IItll. - Greern quartz crystals, spinel.
 g! rmit, cryst. pyrite, molyblemitr, molybdut, chalcopy rite, kaolin, ust. ninite, musconiti, orthoclase, bismutite.

Cimchester.-Near 'Trainer's milldam, beryl, tourmaline, crystals of feldspar, kaolin ; on Wm. Fyre's farm, tourmaliur.

CONCORD - Mica, fiddopar, haolin, drusy quertz, meersehamm, stel. lated tremolite, anthophyllite, fibrolito, acicular crystals of rutile, perope in quartz, amethyst, actinolite, manganesiain garnet, beryl; in Ureen's creek, pyroper gurnet.

Darbex--Blu' aud yruy 'yanite, garnet, staurolite, zoisite, quartz, beryl, chlorite, mica, limonite.

Edeemontr- - 1 methyst, oxide of manganese, crystals of fetdspur; one mile cast of Edgemont Hall, rutile in quarta.

Green's (beek.-Garnet (so-called pyrope).
Haverford.-Staurolite with garnet.

Marple.-Tourmaline, anilalusite, amethyst, actinolite, anthophyllite, talc, radiatcd actinolite in talc, chromite, drusy quartz, beryl, cryst. pyrite, menaccanite in quartz, chlorite.

Midinetown.-Amethyst, beryl, black mica, mica with reticulated magnetite between the plates, manyancsian garncts! large trapezohedral crystals, some 3 in . in diameter, indurated tale, hexagonal crystals of rulile, "rystals of mica, grech quartz! anthophylliti. radiated tourmaline, staurolite, titanic iron, fibrolite, serpentine; at Lenni, chlorite, green and bronze vermiculite! grecn feldspar ; at Mineral Hill, fine crystals of corundum, one of which weighs 1 ? 1b., actinolite in great variety, bronzite, green feldspar, momstome, sunstone, graphic gramite, magnesite, octahedral crystals of chromite in great quantity, beryl, chalcedony, asbestus, fibrous hormblende, rutile, staurolite, melanosiderite, hallite ; at Painter's Farm, near Dismal Run, zireon with oligoclase, tremolite, tourmaline; at the Black Horse, near Media, corundum; at Hibbard's Farm and at Fairlamb's Hill, chromite in brilliant octahedrons.

Newtown- - Scrpentine, hematite, enstatite, tremolite.
Mpper Providence.-Anthophyllite, tremolite, rudiatcd asbestus, radioted artinolite, toumaline, beryl, green feldspar, amethyst (one found on Morgan Hunter's farm weighing over 'ths.), andalusite! one terminated crystal found on the farm of Jas. Worrell weighs $7 \frac{1}{2}$ lbs.) ; at Blue Hill, very fine crystals of bluc quartz in chlorite, camianthus in serpentine, zircon.
Lower Provmence.-Ametlyst, gren mica, garnet, large crystals of feldspuer! (some owar loo lbs. in weight).
Radnok--(farnt, marmolite, deweylite, chromite, ashestus, magnesite, tale, blue quartz, picrolite, limonite, magnetite.
Spmedrmen.-Andalusitc, tourmaline, beryl, titanic iron, garnet; on Foll's Laurel liill, heryl, garnet; near Beattie's mill, staurolite, npatite ; near Lewis's paper-mill, tourmaline, mica.
Thonnbine - Amethyst.
hintinglon ('O.-Near Franrstown.-In the bed of a stream and on the side of a hill, fibrons celcstite (abmandant), quattz crystals.
hancaster (o.-l)humone Townshif- - Quartz crystals.
Furton.-At Wood's chrome mine, near the village of Texas, brucitr!! zaratite (emerald nickel), pemile! riznidolite! kï̈mmelerite! baltimurite, chromite, williamsite, chrysolit!! marmolite, picrolitc, hydromaguesite, dolomitc, magnesife, arayonite, calcite, serpentine, hematite, menaccanite, genthite, chrome-garnet, bronzite, millerite; at Low's mine, hyfromaymesite, brucite (lancasterite), prionlite, magnesite, williemsits, chromic iron, talc, zaratite, batimorite, serpentine, hematite ; on M. Boice's farm, one mile N. W. of the village, pyrite in cubes and various modifications, anthophyllite; near Rock Springs, chutecdony, carnelian, moss afate, gree $n$ tourmaline in tale, titanic irom, chromite, ortuhedral magnetite in chloritc; at Reynolds's old mine, calcite, tale, picrolite, chromite; at Carter's chrome mine, brookite.

Qar Mines-('halcopyrite, pyrrhntitc (uiccoliferous). millerite in botryoidal radiations, vivianite! (rare), actinolite, sidurite, hisingerite, pyrite.

Peqra Valley.-Fight miles south of Lancaster, argentiferous galenite (said to contain 250 to 300 ounces of silver to the ton?), vauquelinite, rutile at l'equea mine ; four miles N. W. of Lancaster, on
the Lancaster and Marrisburg Railroad, calamite, galenite, blende; pyrite in cubic crystals is found in great abundance near the city of Lancaster; at the Lancaster zinc mines, calamine, blende, tennantite? smithsonite (pseud. of dolomite), aurichalrite.

LEBANON CO. - ConNWAhl. - Maghtite, pyrite (cobaltiferous), chalcopyrite, native copper, azurite, malachite, chrysocolln, cuprite (hydrocuprite), allophane, brochuntite, serpentine, quartz pseadomorphs; galenite (with octahedral cleavage), fluorite, covellite, hematite (micaceous), opal, asbestus.

LEHIGII CO.-Frmedensvmme.-At the zinc mines, culamine. smithsonite, hydrozincite, massive blende, greenockite, quartz, allophane, zinciforous clay, mountain leather, aragonite, sauconite: near Allentown, marnetite, pipe-iron ore ; near Bethlehem, on S. Mountain, allanite, with zircon and altered sphene in a single isolated mass of syenite, magnetite, martite, black spinel, tourmaline. chalcocite.
MIFFLIN CO.-Strontianite.
MONROE CO.-In Cierry Vallidy.-Calcitp, chalcedony, quartz; in Poconac Valley, near Judgo Merrine'm, cryst, quartz.

MON'TGOMERY CO.-CONSHOHOCKEN. -Fibrous tourmaline, menaccanite, arenturine quartz, phyllite; in the quarry of Geo. Bullock, calcite in hexagonal prisms, aragonite.

Lower Providen('e. - At the Perkiomen lead and copper mines, near the village of Shamnonville, azurite, blende, galenite', pyromorphite, cerussite, wulfenite, anglesite, barite, calamine, chalcopyrite, malachite, chrysocolla, brorn spar, cuprite, covellite (rare), melaconite. libethenito, pseudomalachite.

White Marsif.-At 15. O. Ilitner's iron mine, five and a half miles from Spring Mills, limonite in geodes and stalactites, güthite, pyrolusite, wad, lepidocrocite; ut Edge Hill Strent, North Pennsylvania Railroad, titanic: iron, brumite, prolusite; one miles. W. of Hituer's iron mine, limonite, velvety, stalactitic, and fibrous, fibres thret inches long, turgite, güthite, prrolusite, velvet manyanesp, wad ; near Marble Hall, at Ifitner's marble quarry, white marble, granular barite, resembling marble; at Spring Mills, limonite, prolusite, göthite; at Flat Rock Tunnel, opposite Manayunk, stillitc, hu ulundite, chabasite, ilvaite, beryl, feldspar, mica.

Lafayerte, at the Soapstone quarries.-Tale, jefferisite, gapnet, albite, serpentine, zoisite, staurolite, chaleopyrite : at Rose's Serpentine quarry, opposite l afayette, enstatite, serpentine.

NORTHAMPTON CO.-BuaHilll Townshm.-Crystal Spring on Blue Mountain, quartz crystals.

Near Earton.-Zireon! (exhausted), nophrite, coccolite, tremolite, pyroxene, sahlite, limonite, magnetite, purple calcite.

Whllams Townsimp. - Pyrolusite in grodes in limonite beds, göthite (lepidocrocite) at Glendon.

NORTHUMBERLAND CO.-Opposite Smin's Grove. - Calamine.

PHILADELPPHIA CO.-Frankford.-Titanite in gneiss, apophyllite; on the Philadelphia. Trenton and Connecting Railroad, basanite; at the quarries on Frankford Creek, stilbite, molybdenite, hornblende; on the Connecting Railroad, wad, earthy cobalt; at Chestnut Hill, macruetite, green mica, chalcopyrite, fluorite.

Fairmount Water-Wonks.-In the quarries opposite Fairmount,
autronitc! torbernite, crystals of frldspar, beryl, pseudomorphs aftor beryl, tourmaline, albite, wad, menaccanite.

Gorgas's and Creane's Lane.-Tourmaline, cyanite, staurolite, hornstone.

Near Germantown.-Black tomemaline, laumontite, apatate; York Road, tourmatine, beryl.

Hestonvilde.-Alunogen, iron alum, orthoclase.
Ileft's Mnh.-Alunogen, tourmaliue, cyanite, titanite.
Manayunk.- - t the soapstone quarrios above Manayunk, talc, strutite, chlorite, vermiculite, anthophyllite, staurolite, dolomite, apatite, asbestus, brown spar, epsomite.

Mediarcaés I'aper-mill.-Staurolite. titanic iron, byalite, apatít', green mica, iron garnets in great abundance.

Mchinney's Quarix, on Riltenhouse Lame.-Feldejar, apatite, stillite, natrolite, heoldendite, epidote, hornblende, erubescite, malachite.

Somitikill Falls.--C'labazite, titanite, fluorite, epidote, masrovite, tourmaline, prochlorite.

S('IUY゙]KILK CU.-TAMaQCa, near Pottsville, in coal mines.-Fronlinite.

YOLII (.O.-Bornite, rutile in slender prisms in granular quartz.

## DELÁWARE.

NEWCASTLF CO.--Brandrwine Sprinos.- Pucholzite, fibroliti abandant, suhlite, prroxene; Brandywine Ilundred, muscorite, en-- Josing reticulaind maghetite.

Dheon's Ferdspar guanmies, six miles N. W. of Wilmington (guarrese worked for the manufacture of porcelain). - Adelderia, abthite, oligurlase. buryl, "putite, cinnumon-stont!! magnesite, serpentine, asbestus, black toutmaline! (rare), indicolite! (rare), spheue in pyoxene, cyanite.

Dupont's Powden Mills.-"Myprirsthene."
Eastrunn's Limestune Quammes, wear tho Pennsylvania line.Tremolite, bronziti.
qutabryviline.- Garnet, spodumene, fibrolite.
Near Newank, on the railroad.-Siphorosiderite on drusy quarte, jasper (ferrugimous opal), cryst. spathic iron in the cavities of cellular guartz.

WAy's Qtamy, two miles south of Centreville.-Fiddspar in fins cleavare masses, "qutite, mira, dion ylitr, gromular quartz.

Wimmington.-In Christiana quarries, metalleidel diallage.
Kenneit Tunnpike, near Centreville.-(yanite and garnet.
HAR'JTORI) (O.-Dewrylite.
KENT (O.-Near Mndietown, in Wm. Polk's marl pits.-Virianite!

On Cmesapeake and Delaware Cinal.--Retinasphalt, pyrite, amber.
sUsSEX CO.-Near Cape Menlopen.-Vivianite.

## MARYLAND.

Balitmone (Jones's Falls, $1{ }^{3}$ mile from B.).-Chabazite (haydenite), heulandite (beaumontite of Levy), py rite, lenticular carbonate of iron, mica, stilbitr.

Sixteen miles from Baltimore, on the Gunpowner.-Grapltite.
Twenty-three miles from B., on the Gumpowder.-Talc.
Twenty-five miles from B., on the Gurpowder.-Magnitits, sphene, pyenites.

Thirty miles from B., in Montgomery (\%., on farm of S. Eliot.Gold in quarts.

Eight to twenty miles north of B., in limestone. - Tramolite, augiti, pyrit, brown and yellow tourmaline.

Fiftecn miles north of B.-sky-blue chaleadony in granular limestone.

Eighteen miles north of B., at Scott's mills.-Margertits, cyanite.
Bare Mhis.--Cleromite, wshestes, tromolite, tole', hornblende, serpentine, chalcedony, meerschaum, baltimorite, chelconyritc, magnetite.

Cape Sable, near Magothy R.-Amber, pyrite, alumi slate.
('amboll Co.-Near Sykesville, Liberty Mines, gold, magnatite, pyrite (octahodrons), cheilcopyrit', linnaite (carrollitel; at Patapsco Mines, near Fiuksburg, bornite, maldrlite, siegenite, limmoite, remmgtonite, marnetite, cheleopyrite; at Mineral Hill mine, bomitc, chalcuyyrite, ore of nickel see above), gold, magnetite.

Cectl ('o., north part. - ('hromuitc in serpentine.
Cooprown, Harforl Co.- Olive-colored tourmuline, diallage, tale of areen, blue, and rose colors, liguiform aste stus, chomite, supertine.

Deer (reeek - Marfortite! in chlorite slate.
Frederick ('o.- Old liberty mine, near Liberty Town, hlack copper, mulachite, chaleocite, spernlar iron: at Iollyhyde mine, bornite, chalcopyrite, pyrite, argentiferous galenite in dolomite.

Mon'igomers co.-- Oxide af manguncse.
Somerser and Worcester (os., north part.-Bug-iron ore, vieianit.

St. Marc's River - Gypsitm! in clay.
Pydesville, Harford Co.-Asbesius mine.

## VIRGINLA, WEST VIRGINIA, AND DISTRICT OF COLDMBIA.

Ambemanhe ('O., a little west of the Green Mts.-Steatite, graphite, galenite.

Amberst Co.-Along the west hase of Buffalo Ridge, copper ores; on N. W. slope of Friar Mtn., allanift, magnetite, zircon, sipylite

Augcsta ('o.-At Wryer's (or Weir's) cave, sixteen mile's northeast of Stannton, and eighty one miles northwest of Richmond, calcite, stalactites.

Buekincham Co.-Gold at Garnett and Moneley mines, also, pyrite, pyrrhotite, caleite, qarnet, at Fldridye mine (now London and Virginia mines) near by, and the Buchingham mines near Mayswille, gold, auriferous pyrite, chalcopyrite, temantite, Durite' ; 'ymite, tourmalin', actinerits.

Cinesterfifld (o.-Near this and Riehmond Co., bituminous coal, mative roke.
('viperper Co., on Rapidan River.-(told, pyrite.
Frankinn (o. - (dravish steatite.
Favquien Co., Barnett's mills,-Asbestus, gold mines, barite, calcitc.

Fluvanna (\%.-Gold at Stockton's mine; also tetralymite, at "Tellurium mine."

Phenix Coppei: Mines-Chalcopyrite, etc.
(ieorgetown, D. (i.-Rutile.
(ioocmland (Go-Gold mines (Moss and Bushy's).
Harpler's Ferisy, on both sides of the Potomac.- Thuringite (owenite) with quartz.

Jefferson (o., at Shepherdstown.-Fluor.
Kanawima ( 0 --At Kianawhi, petroleum, brine springs. cannel eoal.
Ioudon ('o.-- Trtbulatr quartz, drase, pyrite, tale, chlorite', sortpstone. asbestas, chromite, actimolite, quartz rrystalds ; mirnceous iron, boruite, malachite, epidote, near laesburg (Potomac mine).

Loulsa Co.-Walton gold mine, gold, pyrite, chalopyrite, argentiferons qulnite, siderite, blende, anglesite; boulangerite, bleude (at Tinder's mine).

Nelson (o.-- Galenite, chalcopyrite, malachite.
Orange (o.-Western part, Blue Ridge, specular iron ; gold at the Orange (irove and V"aucluse gold mines, worked by the "Freehold" and "Liberty" Mining Companies.

Rockinidga Co., three miles southwest of Lexingron.-Burite, strengite.

Simmandoam Co., near Woodstock.-Fluorite.
M't. Admo, Bhe Ridge.-Argillaceous iron ore.
Spottsylvanit (o., two miles northeast of Chancellorville.-Cy. anzte; frold mines at the junction of the Rappahanusek and Rapidna ; on the Rappahanmech (Marshall mone); Whitehall mine, affordines also tedmalyinte.

Ntafrond ('O, wight or ten miles from Falmouth.--Micaceous iron, gold, tedradymate, shber, galenite, viviamor-

Wachingiton (o., eighteen mules trom abingdon.-hoch selt wath (1) 1 ) $\times 1 / 1 \mathrm{~m}$.

Wrane Co. (Austin's mines).-Cerussitc', mininm, phambic or hre, bhond, raldminer, galduite, graphite.

On the Potomac, twenty tive miles morth of Washington City.-Natioe sulphur in gray compact limestone.

## NORTH CAROLINA.

Asire Co.-Malachite, chaleopyrite.
Buncumbe (o. (now called Mirdison Co.)-Corundum (from a boulder), margarite, corundophilite, garmet, chromite, barite, fluenitc, ruthe, iron ores, manganese, zirron; at Nwananoa (app, ryanite.

ByREE Co.-(iold, monazite, zireon, beryl, rormuleme,ternet, sphenf, graphitc, iron ores, tetradymite, montamte (hydrous bismuth tellarate).
(iabammus Co.-Phenx Mine, gold, barite, chalemypite, auriferous pyrite, quartz pseudomorph after barite, tetradymite, montanito: Pi oneer mines, gold, limonite, pyrolusite, barnhardito, wolform, sehcelite, cuprotangstite, tungstite, hamond, chrysocolla, chalcocite, molybdenite, chatconyrite, pypite; White mine, needle ore, chaleopyrne, barite; Lonm and Muse's mine, argentiferous galenite, pyrite, chalcopyrite, limonite : Boger mine, tetradymite ; Fink mine, valuable copper ores; Mt. Makins, tetrahedrite, marnetite, tale, blende, pyrite, proustite, galenite ; Bangle mine, scheelite.

Caldwend Co. - Chromite.
Cinatham Co.-Mineral coal, pyrite, chloritoid.
CImenokec Co.-hron ores, grold, galenite, corundum, rutile, cyanite, damonite.

Cleveland Co.-White ${ }^{\prime}$ 'aians, quartz, erystals, smok'y quartz, tourmaline, rutile in quartz.

Clay Co.-At the Cullakenee mine and elsewhere, corundum (pink), zoisite, tourmaline, margarite, willeoxite, dudleyite.

Davidson (Co.-Kinr's, now Washington mine, native silver, cerussite, anglesite, scheelite, pyromorphite, galenite, blende, malachite, black copper, eracellite, garnet, stilbite; five miles from Washington mine, on Fqust's farm, gold, tetredymite, oxide of bismuth and tellurium, montanite, chalcopyrite, limonite, spathic iron, epidote; near Sigure Ward's, gold in crystals, electrum.

Franklin ('o.-At Partiss mine, diamonds.
Gaston Co.-lron ores, corundum, margarite; near Crowder's Moun:tain (in what was formerly Lincoln Co.), lazulite, cyonite, g/twt, graphite' ; also twenty miles northeast, near south end of ©hbb's Mountam, lazuhte, cyanite, talc, rutile, topar, pyrophyblite; King's Mountain (or bisgrs) mane, native tellurium, altaite, tedradymite, montawite.

Gutrfonn Co.-McCulloch copper and gold mine, twelve miles from (ireeubboro, gold. phate, rhothepyrite (worked for copper), putertz, siderite; copper ore at the old Fentress mine; at Deep liver, compact pyrophyllite (worked for slate-pencils).

Haywood ('u.- ('orundum, margarite, damourite.
Hendenson Co.-Zircom, sphene (xanthitane).
Jackson (o.-Alunogen? at Smoky Mountain; at Wraster, serpentine, chromite, genthite, chrybolite, tale; Lfoghalt Mountain, pink corundum, margarite, tourmalime.

Lincoln ('O.-I) hamond ; at Randleman's, amathyst, rose quartz.
Macon Co-Franklin, culsagee mine, corundum, spmel, dianore, tourmaline, damourite, prochlorite, culsareeite, kerrite, maconite.

McIowell Co.-Brookite, nomazitr, corundum in small erystals, red and white, zircons, garnet, beryl, phene, xenotime, rutile, elantic mandstone, iron ores, pyromelane, tetradymite, montanite.

Mabison Co.-'Twenty miles from Asheville, corundum, margarite, chlorite.

Mechlenbura Co.-Near Charlotte (Rhea and Cathay mines) and elsewhere, chatropyrite, gold ; chalcotrichite at Mediun's mine: barnhardtite near Charlotte; jyrophyllite in Cottom Stone Mountain, diamond; Flowe mine, scheplite, wolframite ; Todd's Branch, momaite.

Mitchell ('o.- It the Wiseman mica mine, muscovite, samer'shite', hatchettolte, euxenite, columbite, rogersite, uraninite, gummite, uraconite, torbernite, autunite; at (irassy Creek mine, muscocite, stmarskite.

Montgomery Co.-Stefle's mine, ripidolite, albite.
Moore Co.- (arbonton, compact pyrophyllite.
Rowan Co.- (inld Ilill mines, thirty-right miles northeast of Charlote, and fourteen from Salisbury, gold, auriferous pyrite; tea miles from Salisbury, fildspur in erystals, lismuthinite.

Randolih C'o.-Pyrophyllite.
Rutnenfond Co.-Guld, graphite, bismuthic gold, diamoud, eaclase,
pseudomorphous quartz? chalcedony, corundum in small crystals, epiclote, pyropc, brookite, zircon, monazite, rutherfordite, samarskite, quartz erystals, itacolunyte; on the road to Cooper's Gap, 'yanite.
stones and Surey Cos.-Iron ores, graphite.
Union Co.-Lemmond gold minc, eighteen miles from Concord (at Stewart's and Moore's mine). gold, quartz, blende, argentiferous galenite (containing 23.4 oz . of gold and 865 oz . of silver to the ton, (ienth), pyrite, some chalcopyrite.

Yancey Co.-Irom ores, amianthus, chromite, garnet (spessartite), samaishite, columbite.

## SOUTH CAROLINA.

Abbeville Dist.-Makland Grove, gold (Dorn mine), galenite, pyro. morphite, amethyst, garnet.

Anderson Dist.--At Pendleton, actinolite, galenite, kaolin, tourmaliup.
('inamieston.-Selenitc.
Cheowee Vallsy.- Gialenite, tourmaline, gold.
('hestenfiduD Dist- - (iold (Brewer's mine), talc, chlorite, pyrophy)lite, pyrite, native bismuth, bismuth carbonate, red and yellow ochre, whetstone, enargite.

Darlington-Kaolin.
Ebrikfienit Mrs.--Psilomelane.
(imetenvines Hist, - (ialenite, pyrominrphite, kaolin, chalcedony in buhrstome, hery?, plumbaro, epidote, tourmuline.

Kenhian mist.- latile.
I Ancas'ser Dist. - (iold (Hale's mine), tale, chlorite, cyanite, itacolumyte, pyrite; gold also at Blackman's mine, Massey's mine, Ezell's mine.

Lathens Dint.-Corundum, damourite.
Newberdy Dist.-- Leadhillite.
Pickens Dist. - Gold, manganese ores, kaolin.
lifculand Dist. - ('hiastolite, novaculite.
Sramtanbuig Dist.-Magmetite, chalcedony, hematite; at the Cowperns, limonite, graplite, limestone, copperas; Morgan mine, leadhillite, pyromorphite, cerussite.

Sumter Dist.-Agate.
Union Dist, - Fairforest gold mines, prite, chalcoprite.
lohk Dist.-Limestones, whetstones, witherite, barite, tetradymite.

## GEORGIA.

Burke and Schiven Cos-Myalite.
Cherohee ('o.-At Canton Mine, chalcopyrite, galenite, clausthalite, plumbogummite, hitchcockite, " prenopgyritc, lanthanite, hurrixite. cantomiti, pyromornhite, automolite, sinc, staurolite, cyanite; at BallGround, spodumeno.

Clank Co., neur Clarksville.-Gold, xenotime, zircou, rutile, cyanite, hematite, garnet, quartz.

Dade Co...-Halloysite, near Rising Fawn.
Fannin Co.-Staurolute! chalcopyrite.

Habersinam Co.-Gold, pyrite, chalcopyrite, galcmite, hornblende, garnet, quartz, kaolinite, soapstone, chlorite, rutile, iron ores, tourmaline, staurolite, zircon.

Hall CO.-Gold, quartz, kaolin, diamond.
Hancock Co.-Agate, chalcedony.
IIearl) ( $0 .-$ Molybelite, quart\%.
Lee Co.-At the Chewacla Lime Quarry, dolomite, barite, quartz
Concoln Co -Lazulite! ! rutile! ! hematite, cyanite, manaccanite, pypron hyllite, gold, itacolumyte rock.

Lowndes Co.-Corundum.
Lumpin Co.-At Field's gold mine, near Dahlonega, gold, tetradymite, pyrrhotite, chlorite, menaccanite, allanite, apatite.

Rabun Co.-Gold, chalempyitr.
Spaulding Co.-Tetradymite.
Washington Co., near Saundersville. - Wavellite, five upal.

## ALABAMA.

Benton Co.-Antimonial lead ore (boulangerite?)
Bibs Co., Centreville.-lrom ores, marbl-, brarite, coal, cobalt.
Cmambers C $\%$ - Near La Fayette, steatite, garnets, actinolite, chlorite; east of Oak Bowery, steatite.

Chilton Co.-Muscovite, graphite, limonito.
('leburne (\%o.--At Arbacoochee mine, gold, prite, and threo miles distant cyanite, garners; at Wood's min black copper, azurite, chalco2yrite, pyrite.

Clay (O.-Steutite; near Delta and Ashland, muscorite.
Coosa Co.--Tantalite, gold, muscovite.
Ranbolph (co.-Gold, pyrite, tourmaline, muscovito; at Louina, porcelain clay, garnet

Talladeha Co.-Limemite.
Tallapoosa Co., at Dudleyville--Corundum, margarite, ripidolite, spinel, tourmaline, actinolite, stfatite, asbestus, chrysolite, damourite, corundum altered to tourmaline (crestals of the latter containing a nucleus of the former) and also otber pseudrmorphs, including, at Dudleyville, dudleyite.

Ttiskaloosa Co.-Conl, galenite, pyrite, vivianite, limonite, calcite, dolomite, cyanite, steatite, quartz crytals, mauganese ores.

## FLORIDA.

Near Tampa Bay.-Limestone, sulphur springs, chalcedony, carnelian, agate, silicified shells and corals.

## KENTUCKY.

Anderson Co.-Galenite, barite.
Clinton Co.-Geodes of quartz.
Chittenden Co.-Galenite, fluorite, calcite.
Cumberland ('o.-At Mammoth Cave, gypsum rosettcs! calcite, stalactites, nitre, epsomite.

Fayette Co.-Siz miles N. E. of lexington, galenite, baritr, withrite, blende.

Livingeston (\%., near the line of Union Co,-Galenite, chatcopyrite, large vein of tluorite.

Mercer Co.-At McAfee, fluorit', pyrite, calcite, barite, celestite OwEN Co.--Galenite, barite.

## TENNESSEE.

Brown's Creer.- Galenite, blende, barite, celestite.
Carter Co , foot of Roan Mt.--Sillulte, magnetite.
Clambine Co.-Calamine, galenite, smithsonite, chlorite, stcatite, magnetite.

Cocke Co, near Bush Creok.--Cacoxenite? kraurite, irou sinter, stilpnosiderite, brown hematite

Davidson ('o - Sclenite, with granular and snowy gypmem, or alabaster, crystallized and compact nuhydritc, Jthorite in crystals? caltote. in crystals Near Nashville, blue idextite (erystallized, fibrous, and radiated), with lucritc in limestone. Haysboro', galenite, blende, with barite as the gangue of the ore.
Dit'kson ('o.-Manganite.
Jefferson ('o.- (ith mime, galenite, fetid barite
K nox ( 0 o.-Magnesian limestone, mative iron, variegated marbles!
Maury (o. -. Wavellite in limestone.
Moncan ('o.-Epsom salt, nitrate of lime.
Pons Co. Ducktown mines, southeast corner of State.-Melaconite, chalcoprrite, pyrite, native copper, bornite, rutile, zonite, galenite, harrivile, alisonite, bleude, pyrurcue, tromolite, sulphates of rmper ant irom in stalactites, allophane, rahtite, chalcocite (ducktownite), chalcotrichite, azurite, malachite, pyrrhotite, limonite.

Roan ('o., easterly declivity of Cumberland Mts. - Wavellite: in limestone.

Sevier Co., in caverns.-Epsomite, soda alum, nitre, nitrate of calcium, brececia marlle.

Smith Co.-Fluorite.
Smoky Mт., on declivity.-Hornblende, grarnet, staurolite.
Whime Co.-Nitre.

## orillo.

Barnmmade (Copperas Mt., a few miles cast of B.).-Calcite, barite, pyrite, copperas, alum.

1)uck (heek, Monroe Co.-Petroleum.

Lake Fine.-Strontian Island, celcstite! Put-in-Bay Island, celestite! sulphur! calcite.

Liverpool.-Petroleum.
Marietta.-Argillaceous iron ore - iron oro abundant also in Scioto and Lawrence Cos.

Ottawa Co.-Gypsum.
Poland.-(rypsum!

## MICHIGAN.

Brest (Monroe Co.).-Calcite, amethystine quartz, apatite, celestite. Grand Rapids. - Selenite, fib. and granular gypsum, calcitc, dolomite, anlydrlite.

Lake Superior Mining Region.-The four principal regions are Keweenaw Point, Isle Royale, the Ontonagon, and Portage Lake. The mines of Keweenaw Point are along two ranges of elevation, one known as the Greenstone Range, and the other as the southern or Bohemian Range (Whitney). The copper occurs in the trap or amygdaloid, and in the associated conglomerate. Nittive comper! mutwe silatr! chalconyrite, horn silver, tetrahedrite, manganese ores, epidote, preflente, lummentite, datolite, heulandite, orthoclase, arulite, chabazite, compact dutolite, chrysocolla, mesotype (Copper Falls mine),
 (ib.), calcite, quartz (in crystals ut Minnesota mine), compact datolite. orthoclase (Superior mine), sponitc, melaconite (near Copper Harbor, but exhausted), chrysucolla; on Chocolate River, galenite and sul. phide of copper; chalcopyrite and native copper at Presq'Isle ; at Albion mine, domrykito; at lrince Vein, berite, calcite cmothyst; at Albany and Boston mine. Portage Lake, prchnite, aralcite, orthurluse, cuprite: at Sheldon location, chmmeykit, whimuite, alyodenite; Quincy mine, calcite, compact datolite. At the Spur Mountain iron mino (magnetite!, chlorite ${ }^{\text {sseudomorph after garnet ; Isle liovale, datolite, }}$ prehnite.

Marquette.-Mauganite, grlenite ; twelve miles west at Jackson Mt., and other mines, homutitr, lomonite, gothite!' magnetite, jasper.
Monfoe.-Aragonite, aputite.
Point ale Peacx (Monroe Co.)-Amethystine quartz, apactitc, celes. tite, calcitt:

Sacinaw Bay.-At Alahaster, gypsum.
Stony Point (Monroe Co.)-Apatite, amethystine quartz, celestite, calcite.

## ILLINOIS.

Gallatin Co., on a branch of Grand Pierre Creek, sixteen to thirty miles from Shawneetown, down the Ohio, and from half to eight miles from this river.-Violet fluorite! in carboniferous limestone, barite, galenite, blende, brown irom ore.

Hancoce Co.-At Warsaw, quatza geofers containing ralrite! chatculdny, dolonite, llende! brown spar, pyrite, aragouite, gypsum, bitumen.

Hardin Co.-Near hosiclare, calcite, galenite, blende; five miles back from Elizabethtown, bog iron; one mile north of the river, between Elizabethtown and Rosiclare, nitre.

Jo Daviess ('o.-At (ialena, grlcnite, calcite, pyrite, blende; at Maruden's diggings, galenite! blende, cerussite, marcasite in stalactitic forms, pyrite.

Joliet. - Martle.
Quincy.-Calcite! pyrite.
scales Mound.-Burite, pyrite.

## INDIANA.

Limestone Caverns; Corydon Caves, etc.-Epsom salt.
In most of the southwest countres, pyrite, iron sulphute, and foather alum; on Sugar Creek, pyrite and irou sulphate; in sandstone of hoyd Co., near the Ohio, gypsum ; at the top of the blue limestone formation, brown epar, catcite.

Lambence Cu.-Spice Valle, kaolinite (=indianaite).

## MINNESOTA.

Nomth Sifore of LL. Superion (range of hille running nearly northeast and mouthwest, extending from Fond du Lac superieure to the Kamanistigueia River in Upper ('anada).-Srolecite, apophyllite, prehnite, stilhite, laumontite, heulandite, harmotome, thomsonite, fluovite, barite, tourmaline, equidete, hornbleude, calcite, quartz crystals, pyrite, magnt-tite, steatite, blende black oxide of copper, malachite, native copper, chalcopyrite, amethystine quartz, ferrugiuous quartz, chalceelony, carnelimu, agate, drusy quartz, hyalite? fibrous quartz, jasper, prase (in the debris of the lake whore), dogtooth spar, augite, native silyer, npodumene? chlorite, between Pigeon Point and Fond du Lac, near Baptism River, saponite (thalite) in amygdalod.

Getthe River Tral liange.-Epidote, nail-head calcite, amethystine quarta, calcite, undetermined zeolites, saponite.

Sthinater.--Birnde.
Fahds of the 't. Chorx.-Malachite, native enpper, epidote, nailhead apar (calente).

Rany lafib.-Actinolite, tremolite, fibrous hornblende, garnet, pyrite, magnetite, steatite.

## WISCONSSIN.

Big Bolis Falls (near).-Bog iron.
Blute Mounds.-(erussite.
Hazel (ikeen. - Caicite.
Lacinf Flambliau R.- (iarnet, cyanite.
Left-Mand R. (hear small tributary).-Malachite, chalcocite, native copper, cuprite, malachite, eqidote, chlorite? quartz erystals.

Linden.- Cřheuite, smithsonite, hydrozine ite.
Mineral Pornt and vicinity.-Copper and lead ores, chrysocolla, azurite! chalcopyrite, malachite, gal nite cerussite, anglesite, blende, pyrite, harite, calcite, marrasite, smithsonite! (including pseudomorphs after calcite and blende), (so-called "dry-bone"), calamine, bornite, hydrozincite.

Montreal, Rivier Portage - Galenite in gneissoid granite.
Savi ('O.-Hematite, malachite, chalcopyrite.
Suulbsbura.-Galenite! Blende, pyrite ; at Emmet's digroing, gacnite and pyrite.

## IOWA.

Dut Brque Lead Mines, and elsewhere.-Galenite! calcite, blerede. black oxide of manganese ; at Ewing's and Nherard's diggingr, smith-
sonite, calamine; at Des Moines, quartz crystals, selenite; Makoqueta 12., limonite; near Durango, galenite.

Cenar River, a branch of the Des Moines.-Selenite in crystals, in the bituminous shale of the coal measures ; also elsewhere on the Des Moines, gypsum abundant; argillaceous iron ore, spathic iron: copperas in crystals on the Des Moines, above the mouth of Saap and elsewhere, pyrite, blende.

Font Donak.- (ielestite.
Makoqueta.-Hematite.
New (ialena.-()ctahedral galenite, anglesite.

## MISSOURI.

For the distribution of the lead mines see page 147. The number of minerals associated with the lead ore varies greally in the different lead regions. Mine la Motte. and some old openings in Madison C'o., are peculiar in affording cobalt and nickelores abondantly. At (iranby and other mines the chief anc ore is calamine, or the siheate of zinc, while in the mines of Central and Nouthwest Missouri it is comparatively rare, and smithsonite is the prominent ore-as is the case in Wisconsin; yet calamine is the most abundant zinc ore in the state. As stated by A. Schmidt, the zine ore, in each case. is found an a secondary product to sphalerite (blende) ; the cerussite often coats the galenite, or has its forms, indicating thus its source; the limonite is also secondary, and has come in manly through the oxidation of pyrite. At the (iranly mines, the ralamme is called, among thr miners, "Black Jack ;" blende, " Resin Jack:" a white massive smithsonite, "White Jark;" and the cerussite is the "Dry Bone;" thus departing from ordinary miners' usage. Gold has been found in the drift sands of Northern Missouri (Broadhead).

Adarn C'o.-(rothite in calcite.
Bamton ('o.-Pickeringite as an efflorearnce on sandstone.
Gmariton (o-Near salisbury, gypsum in com beds.
 chalcopyrite, malachite, azurite, prite, calcite, calamine, mphaterite.

Jron Co.-At Pilot Knob and Whepherd Mountain, hematite, magenftite, limenite, manganese oxide, bog manganese.

Jasper Co. (adjoins S. E. Kansas). - At Joplin mines, gatena! sphorLerite, pyrite, cerussite, calamine, dolomite, bitumen.

Jefferson (O.-At Valle's, galenite! cerussite, anglesite, colemine. smithsonite, sphalerite, hydrozincite, chalcopyrite, mahachite, azurite, pyrite, barite, witherite, limonite. At Frumet mines, $8 \pm$ miles from De Soto R. R. station, galena, barite! smithsonite! pyrite, hmaite.

Majison (Co.-At Mine la Motte, fralenite! cerussite! siegenite (nickelliuneire), smaltite, asbolate (earthy black cobalt ore), bog manganese, chaleopyrite, malachite, caledonite, plumborummite, wolframite.

Mongan (O.-At Cordray Diggings, galena, blende, burite.
Newton Co. (adjoins S. E. Kansas).-At (iranby mines, gutlenite! cerussite, calamine! sphalerite, smithsonite, hydrozincite, grecnochite (on sphalerite), pyromorphite, dolomite, calcite, bitumen.

Pulaski Co.-In caves, nitrr.
St. Fuancors Co.-Iron Mountain, hematite, limonite.

St. Lours Co.-Near St. Louis, millerite (in the Subcarboniferous St. Louis limestone, largely a magnesian limestone) with calcitc! barite, flumrite.

Washington (\%.-At Potosi (Mine à Burton), galenitc, corusbite, anglesite, barite, calcite.

## ARKANAAS.

Batesville.-In bed of White R., some miles above Batesville, gold.
(inefen ('o.-Near Gainesville, lignite.
Hot spmings ('o.-At Hot Springs, wavellite, thuringite; Magnet G'ove, brookite! schorlomite, elaolite, magnetate, quartz, green roccolite, yorruet, apatite, purofolite (hydrotitanite), rutile, rapidolite, thomsonite (ozarkite), mirroclime, ayorite, protovermiculite.

Indelphinence (o-Lafferay (reek, psilomelane.
Labrence ('O.-Hoppe, bath, and Koch mines, smithsomatc', dolomite, gralenite; nitre.

Marion (co.-Wood's mine, smithsouite, hydrozincito (marionite), galenite ; Poke bayou, lrannite?

Montcomery (o.-Variscite.
Ouachita Springs.- Quartz? whetstones.
Pulaski ('o.-Kellorg mine, 10 m . north of Little Rock, tetrakedrite, tennantite, nacrite, gralenite, blende, quartz.

## CALIFOINNIA.

The principal gold menes of California are in Tulare, Fresno, Mariposa, Tuolumne, Calaveras, El Dorado, l'lacer, Nevada, Yuba, Kirrra, Butte, Plumas, Shasta, Siskiyou, and Dol Norte counthes, although gold is found in almost every county of the state. The grold occurs ia quartz, associated with sulphides of iron, copper, zinc, and lead; in Calaveras and Tuolumne counties, at the Mellones, Stanislaus, Colden Rule, and Rawhide mines, associated with tellurides of gold and shver; it is also largely obtained from placer digerings, and further it is found in beach washings in Del Norte and Klamath counties.

The copper munes are principally at or near ('opperopohs, in Cala. veras County; mear (ienesfe Valley, in Plumas County; hear Low Jivide, in Jid Norte ('onnty ; on the north fork of Sminh's River, at Soledad, in Los Angeles county.

The merrury mincs are at or near New Almaden and North Almaden, in Santa Clara County ; at New Idria and Nan Catos, Mouterey County; in san Luis Obispocounty ; at Pioneer mine, and other localities in Lake (ounty ; in Nanta Barbara County.

Alameda (co.--I) iabolo Range, magnesite.
Alpine ( ${ }^{\circ}$ o. Morning Star mine, chargite, stephanite, polybasite, barite, quarl\%, pyrite, tetrahedite, prargyrite.

Amainor Co - At Volcano, chalcedony, hyalute': Lone Valley, lonite : Fiddletown, diamond.

Butte ( 0 - - (herokee Flat, diamond, platiumm, iridosmine.
Calavemas Co.-(opperopolis, chaleopyrite, malachite, azurite, serpentine, picrolite, native copper: near Murphy's, jasper, opal, abite, with gold and pyrite; Mellones mine, calautrite, pitzite.

Co.-San Antonio, chalcedony.
Del Nonte Co.-('rescent City, agate, carnelian; low Divide, chat. copyrite, bornite, malachite ; on the coast, iridosmine, platinum, gold, zircon diamond.

El Doraro ('o.--Pilot Hill, chalcopyrite; near (Georgetown, hessite, from placer diggings: Rowrer's ('lam, Hope Valley, groswnlar garnet, in copper ore; Coloua, chromite; Spanish Dry Dicgness, gold ; (iranite Creek, roscoelte, gold; Forest Hill, diamond: Cnsumnes mine, molyblenite.

Fresno Co.-Chowchillas, andalusite ; King's River, bornite.
Hembondt Co.--Cryptomorphite.
Inyo Co.--Inyo district, galenit, cerussite, anglesite, barite, atacamite, calrite, grossular garnct! Surprise Mine, tetrahedrite ; Kearsarge mine, silver ores; Cerro Gordo, wulfenite.
fiern co.-(Xreen Monster mine, cuproscheelite.
Lake (o --Borax Lake, borax! sassolite, glauberite; Pioneer mine, cinnabar, native mercury, selenide of mereury; near the Geysers, sulphur, hyalite; Redington mine, metacinnabarite; Lower Lake, chromite.

Los Angeles Co.-Near Santa Anna River, auhydrite ; Williams Pass, chalcedony; Soledad mines, chalcopyrite, yaruct, gypsum : Mountain Meadows, garnet, in copper ore.

Mariposa Co.--('haleopyrite, itacolumyte ; Centreville. cimabar ; Pine Tree mine, tetrahedrite: Burns Cretk, limonite; Geyer Gulch, prrophyllite; La Victoria mine, azurite! near Coulterville, cinnabar, ford

Mono ('o.-Partzite (stibiconite).
Monterey Co.-Alisal mine, arsenic ; near Pancches, chalcednny : Now Idria mine, cinnabar; uear New Idria, chromite, zaratite, chrome garnet ; near Pachecors Pass, stibnite.

Napa ('o.-Chromite.
Nevada Co.-(irass Valley, gold! in quartz veins, with prrite, chalcopyrite, hende, arsenopyrite, galenite, quartz, biotito; near Truckee Pass, gypsum: Excelsior Mine, molyhdenite, with gold; Sweet Land, prolusite.

Placer ('o-Miner's Ravine, epidate! with quarta, gold.
Plemas Co.-Genesee Valley, chalcopyrite ; Hope mines, bornite, sulphur.

Santa Burbara Co - San Amedio Cañon, stibnite, asphaltum, bitumen, maltha, petroleam, cinnabar, iodide of mercury; Santa Clara River, sulphur
San Bernardino Co.-Colorado River, agate, trona; Temeseal Mts., cassiterite; Russ District, galenite, cerussite : Francis mine, cerargyrite; Slate Range, thenardite, borux, common salt ; San ler nardino Mts., graphites.
Santa ('lara Co.-New Almaden, cinnubar, calcite, aragonite. serpentine, chrysolite, quartz, aragotite ; North Almaden, chromitr ; Mt. Diabolo Range, magnesite, datolite, with vesuvianite and garnet.

San Dieto Co,-Cariss! Creek, gypsum; San lsabel, tourmaline, orthoclase, garnet.

San Francisco Co.-Red Island, pyrolusite and manganese ores.
San Luts Obispo Co.-Asphaltum, cinnabar, native mercury, chromite.

Sinasta Co.-Near Shasts Citz, hematite, in large masses.
Sierra Co.-Forest City, goid, arsenopyrite, tellurides.
Siskivou (o.--Surprise Valley, selenite, in large slahs.
Sonoma (co-Actinolite, garucts, chromitc. kerpentinc.
Ticlare Co.-Near Visalia, magnesite, asphaltum.
Tlolumne Co.-Tourmaline, tremohte; Sonora, graphite; York Tent, chromite ; Golden Rule mine, prtzite, calaverite, altcite, hessite. magnesite, tetrahedrite, gold ; Whiskey Hill, g,ld!
'Ímity ('o --Cassiterite, a single specimen found.

## LOWER CALIFORNIA.

La Paz.-Cuproscheelite. Loretto.-Natrolite, siderite, relonite.

## UTAH.

Beaver Co.-Bismuthinite, bismite, bismutitr.
Tintic District.--At the Shoebridge mine, the Dragon mine, and the Mammoth vein, cuargite with pyrite.

Box Einmer co.-Fmpire mine, wulfcnite!
Utaif (co.-Ammonia alum.
In the Wahsatch and Oquirrh mountains there are extensive mines, espocinlly of oren of lead rich in silver. At the Fimma mine occur gralenite, cervantit-, cerussit", wulfenite, azurite, malachite, calauine, anglesite, liwarite, sphalerite, pyrite, argentite, stephanite, etc. At the Lucky Boy mine, Butterfield (añon, orpinacnt, realgar.

One hundred and twenty miles southwest of Salt Lake City, topoz has been found in colorless crystuls. At a silver mine, fibrous sepiolite.

## NEVADA.

Catson Tamex.-Chrysolite.

Comstock Lode- (xold, native silber, argentite, stephanite, polybasitc, pyrargyrite, proustite, tetrahedrite, cerargyrite, pyrite, chaleopyrite, gralenite, blende, pyromorphite, allemontite, arsenolite, guarta, calcite, gypsum, cerussite, coprite, wulfenite, amethyst, kustelite.

Elкo Co.-Emma Mine, chrysoeolla.
Esmeralda Co.-Alum, 12 m . north of Silver Creek; at Aurora, fluorite, stibnite ; near Mono Lake, native copper and cuprite, ohsidian; Thiel Salt Marsh, ulexite. borax, common salt, thenardite; Columbus district, ulexite, thenardite, sulphur; Walker Lake, gypsum, hematite; Nilver Peak, salt, saltpetre, sulphur, silver ores.

Humboldt District.-Sheba mine, native silocr, jamesonter, stibnitic, tetraheclrite, proustite, blende, ecrussite, calcite, bournonite, pyrite. galenite, malachite, xanthocone (?), cuprite.

Lander Co.-Austin, polybasite, chalcopyrite, azurite.
Lincoln (o.-Rock salt, cerargyrite.
Mammoth Dietriet.-Orthochas", turquoise, hübnerite, seheelite.
Nye Co.--Auglesite, stetefeldite, azurite, cerussite, silver cros, corargyrite.

Reese River Distmict.- Nativo silver, yroustite, purargyrite, stephanite, blende, polybasite, rhodochrosite, embolite. tetrohedrite! curargrite, embolite.

San Antonla.-Belmont mine, stetefeldtite.
Six-Mile ('afon.-Siclenito.
Ormsiby Co.-W. of Carson, opidote.
Stonify C'o.-Alum, natrolite, scolecite.
Wime Prne Co.-Eberhardt mine, cerargyrite ; Paymaster mive, freieslebenite.

ARIZONA.

To the south, south of Tueson, near the Mexican loundary the region about Tubac Arivaca, the Santa Rita and the Patagonia Mts., noted for silver mines, the ore in part argentiferous gatemte; about Tucson, copper ores; a little to the north, the Ileintzelmann mine, Stromeyerite, chalencite, tetrotledrite, native silver, atacamite; on and near the Colorado River, in Xuma County, the (astle lome, Eureka and other mines, of gold, silver, and copper, argcotiferous foulcwite the prominent silver ore. In the lenal range, gold; on the Sun Franciseo River, nativo copper, covellite, chalcopyrite, malachite, azurite; at Bill Willians Fork, malachite, chrysocolla, ataramite, brochantite; Montgomery mine, Harsayampa district, tetradymite.

North of the (iila, just west of the boundary of New Mexico, chalcocite, cuprite', mulaclite.

## OREGON AND WASIINGTON.

dold is obtained from beach washings on the sonthern eorst ; quartz mines and placer mines in the Josephine district ; also on the Powder, Burnt, and John May's rivers, and other places in Eastern Oregon; Matinumi, irifosmine laurite, on the liogue River, at Pori Orford, and ('ape Blanco In Curry ('o., prierite.

At seattle, Washington 'T.--Scheclite, tourmaliue; at Fidalgo, realgar.

## ID AHO.

In the Owyhee, Boise, and Flint districts, gold, also extensive silver mines: Poor Man's Lode, cerargyrite! proustite, pyrargyrite! nutice wiloer, fold, pyromorphite quartz, malachite, stephanite ; polybasite : on Jordan Creek, stream tin; Rising Star mine, stephetite, digentite, pyrargyrite; Charity wine, Warren's, scheclitc, gohe.

## MONTANA.

Many mines of gold, cte., west of the Missouri River. IIrgmand


In the Yellowstone Park, in Montana and Wyoming Territories.-Gryserite, aurcthyst! chulcedony, quartz crystals, quartz on calcite. etc.

## COLOLADO.

The princupal gold mines of Colorado are in Boulder, Gilpin, Clear Creek, and Jefferson Connties, on a line of country a few miles W. of Ienver, extendiug from Long's leak to l'ike's l'eak. A large portion of the gold is associated with veins of pyrite and chalcopyrite; silver and lead mines are at and near Georgetown, (lear Creek County, and to the westward in Summit County, on Snake and Swan rivers.

At the Geongetown mines are found :--native silver, pyrargyrite, argentite, tutrahedrite, pyromorphite, galenite, sphalerite, azurite, aragonite, barite, fluorite, mira.
'Traml Cheme- (darnet, apidote, homblende, chlomite : at the Freeland Lode, thethedrite, temnantite, anglesite, caledonite, cerussite, tenorite, siderite, azurite, minium ; at the Champion Lode, tenorite, azurite, chrysocolla, malachite ; at tho Gold Belt Lode, vivianite ; at the Kelly dode, tenorite ; at the Coyote Lode, malachite, eyanotrichit.

Near Black Mawn.--At Willis Gulch, enargite, fluorite, pyrite; at the Gilpin County Lode, cerargyrite ; on Gregory Hill, feldspar ; North Clear Creek, lievrite - Galcuite!

Bear ('meek.-Fluorite, beryl ; near the Malachite Lodr, matachito, cuprite, vesuvianite, topazolite; Liborty lede, chalcorite.

Snake River.-Peun District, cmbolite; at several lodes, pyrargyrite, native silver, azurite.
 cnitc.... Epidnte, pyritr:

Viroinia Cafun.-Epidute, fluorite; at the Crystal Lode, native silver, spinel.

Slicar Loaf District. - ('halcocite, pyrrhotite, garnet (manganesian).
('entral Cify.- Carnet, tenorite; at leavitt Lode, molybdenite; on Gunnell IIIl, magnetite; at the Pleasant view mine, cerussite.

Gomben City.-Aragonite; on Table Mountain, leucite in anygrdaloid.
linergen's Rancme - (atarnet, actinolite, calcito
Boulder ('O.-Red Cload Mine : Native tellurimm, altaite, hessite (petzite), sylvanite, calaverite, sehirmerite. Keystone Mine: Coloradoite, magnolite, ferotellarite, tellurite, roscoelite? also part of these at Smaraler mine and Mountain Lion mine. Grand View mine : sylvanite, ete.

Lake (ity, at the Motehkiss lode. - Prtaite, calaverite (?), etc.
Lake ( 0 , Qolden Queen mine. - Scherlete, gold.
 turime foldsutr, amethyst, alhite, fluorite, hematite, anhydrite (rare), columbite.

San Juan District.-Gold, sphalerite, pyrite, galenite, chalcocite, covellite, chalcopyrite.

## CANADA EAST.

Abercrombif.-Labradorite.
Aubert.- - (iold, iridosmine, platinum.
Baie st. Paul.-Menaccanitc! apatite, allanite, rutile.

Bolton.- Chromite, maghosic', scrpentane, jierolite, stctitc, bitter spar, wad, rutile.

Boucherville.-Augite in trap.
Brome.-Mhentite, chalcopyrite, spherr, menaccanite, phyllite, sodalite, caucrinite, galenite, chloritoid, rutile.

Brovgiton.-Serpentine, steatite.
Chambly.-Analcite, chabazite and calcite in trachyte, momerentite.
Comateat Richer.-- Iabrudorite, hypersthru', andesite.
Imallebout.-Blue spiuel with clintonite.
Grenville.-Wollastonite, sphene, memoritt, vesuvianite, calcite, pyroxene, serpentine, steatite (rensselacrite), chondrodite, formet (cin-namon-stone), sirrom, (friphite, screpolite.

Fitzroy. Graphite.
Ham.-Chromite in serpentine, diallage, antimen!!! semermumtito! 7. ©rmosite, valentimite, stimite.

IIENTERSTOWN.-Simmiti, sh/me, vesuvianile, garnet, hroirn tourmatine!

Invernfss.... Bornite, chalcocite, prrite.
lake St. Francis.- Ahdoluste in mica slate.
LeEDS - Dolumite, chalcopyrite, grold, chlorituid, chaloocite, bomite, ryrite, sfortitc.

Mrles IsLes.-Lurbruldrite! memaccanite, hyperstheme, undesife, ziston.

Moxtreal.-Calritc, augitr, spheme in trap, chry:olite, natrolite, dawsonite.

Momin - Splarir, apatiti, lamadmrit.

Ottawa.-I'ypurtue.
Portafe de Font.-Rensselaerite.
Potron.-Chromite, statitc, serpentine, amianthus.
Roveremont.-Augite in trap.
St. Armand - Minceous irom ore with quartz, epidote.
St. Francors Beauce-Gold, platinum, iridosmine, menaccanite, magnetite, serpentine, chromite, suapstone, barite.

ST. Jehome.-Sphm, "potite, chaudronlite, phingmiti', tomermatine, zircor, f(fruct, molybdenite, pyrrhotite, wollastonite, luthruduritc.

St. Nonbent.-Amethyst in greenstone.
Sherbrook.-At Sulfiod mine, allite! matioe si?cr, argentite, chalcopyrite, blende.

SoUTH (rosny.- (hondrodite.
Stukelex.-Serpentine, vert-entique! sehiller spar.
Sution. - Mofuetitr, in fine crystals, hrmatite, rutile, dolomite, morgurite, chromiferons tuld, bitter spar, steatite.

Upron- - haleopyrite, malachite, calcite.
Vardmevul--Timonite, vivianite.
Yamasia.--Sphene in trap.

## CANADA WEST.

Arnprior.-Calcite.
Balsam Iake.-Mchyddenite, scapolite, quartz, prosene, pyrite.
 (albite), bytumit', pyroxene, wilsonite, scapolite, nuatite, titanite.

Mrantrond.-Sulphuric acid spring (4.2 parts of pure sulphuric acid in 1,000 ).

Bhock villes.-Pyrite.
Brome.-Magnetite.
Bruce Mines on Iake IIuron.-('alliti, dolomite, quartz, chatcopygit, chulioritic.

Bunaess.--I'yroxrme, albite. mirn, corundum, spheme, ehalcopyrite, "puelite, Wewli spmal! spodumene (in a boulder), serpentine, biotite.

Byrown.-Cetlité, byfornitr, chondrodite, spincl.
Cape Iprerwasif, Lake Huron.-Oxalite in shales.
Ghavdierle Valley.-(iold, sphalerite, pyrite, pyrrhotite, galenite.
Clambadon.-Vesemianit, tomrmaliuc.
Thaliousie.-Hornblende, dolomite.
Drummond.-Lubradorite.
Elizabethtown. - P!/r'hotite, pyrite, calcite, magnetite, tale, phlogopite, siderite, apatite, cacoxenite.

Elmshay.-Pyroxene, sphene, feldspar, tourmuline, apatite, biotite, zircon, red spines, chondrodite.

Fitzroy.-Amber, hrown tombutine, in guartz.
Ggetinest liver, Blasdell's Mills.-('alcite, apatite, tourmaline, hornblende, prroxene.

Grand Chumet lsland.-Aputite phlegropite! pyprortu!! hornblende, sphene, warrimitr!! surpentine, tremolite, srapulitr', brown and black tmermolime! pyrite, loganite.

Miaif Falas of the Miadawaska.-Pyroxtme! hornblende.
Hust.-- Mught:t, parnet, graphite.
Montingeon.-- (relicite!
Innlshilien.- Potroleum.
Kingston - - (elesite.
LaC ines Chats, Island Pordage.-Drome tommotine! pyrite, calcite, quartz.

LaNARK.-Raphilite (hornhlende), serpentine, arbestus, perthite (aventurine foldspar), peristerite

LaNsionwne. - Petrita! vein 27 in . wide, and fine crystuls, rens. selacrite, sphalerite, wilsonite, labradorite.

Madoc-Magnctite.
Marmora.-Magnctite, chalcolite, serpentine, garnct, 'psomite, specular iron, stratite.

Mc Nabs- Hematite, barite.
Michificoton Jsiand, Lake Superior.-Domeykite, mimita, fitwthit', whlcop!yitr, native copper, native silver, 'hateocite, ralenite, muetlyst, calcite. stilbite, analcite. At Maimanse Bay: Coracite, chalcocite, chalcopyrite, native copper.

Newborocial- (thomdrodits, graphite.
Pakenuav.-Homblende.
Prath.-Apatite in large beds, phlogopite.
St. Apele.-Chondrodite in limestone.
St Ignice Ishani)- Cerlcite, native sopper.
Shlyen Id., Lahe Suprerior.--Argentito, native silver, galenite, niccolite, chateocite, malachite.

Sydenilam.- Celestite.
Terrace (oye, lake Superior.-Molybdenite.
Wallace Mine, Lake Huron.--Mematite, nickel ore, nickel vitriol, chalcongrite.

## NEW BRUNSWTCK.

Albert Co.- Hopewell, gypsum ; Albert mines, coal (alluertito); Shopody Mountain, alunite in clay, calcite, pyrite, munfruitc, psilomelane, juyrolusite.

Carleton Co. - Woodstock, chalcopyrite, hematite, limonite, wad.

Cmambotte Co --Campobello, at Weldhpool, blende, chalcopyrite, bornite, fralenite. pyrite; at head of Harbor de Lute, galenite; Deer Island, on west side, calcite, magnetite, quartz crystals; ]ligdighash River on west side of entrance, crlcitr! (in conglomerate), chalcedony ; at Rolling Dum, graphite ; Grandmanan, between Northern Head and Dark Harbor, agate, amethyst, "pephyplite, rolcite, hematite, heulandite, jasper, magnetite, natrolite, stilhite: at Whate C'ove, colcote! heulandite, lammontite, stilbite, semi-mph!.'; Wagagundavie River, at entrance, azurite, chalenpyrite in veins, malachite.

Giouchster Co.-Tete-a-Gouche River, eight miles from Bathurst, chnlconyrite (mined), oride of maruganse!! formerly mined.

Kings (o.--Sussex, near Cloat's mills, on road to Belleisle, argentiforoas galenite; one mile north of Baxter's Inn, "pectuler iron in crystals, lmonite : on Cajot McCready's farm, selcnite!!

Reswhoutme Co.-Belledune Point, calrite! se ripentine, verd-antiqu, ; Dalhomsie, agate, carnelian

St. John Co - Black River, on coast, calcite, cilorite, chalcopyrite, hematite! Brandy Brook, epidote, hornblende, quartz crystals; ('urleton, near Falls, calcite; Chance Harbor, calcite in quartz veins, chlorite in argillaceous and talcose slate; Little Dipper Harbor, on west side, in greenstone, amethyst, barite, quartz crastals; Monsopath, feldspar, hornblende, muscovito, black tourmaline; Masduash, ou cast sidr harbor, copperas, graphite, prite; at Shannon's, chrysolite, serpentine ; east side of Musquash, quirtz erystals ! P Portland at the Falls, graphite : at Fort Howe Hill, ralcite, graphite: C'row's Nest, asbestus, chrysolite, magnetitr, serpentine, steatite: Lily lake, white augite" chrysolite, graphite, serpentine, steatite tale ; How's Road, two miles out, epidote (in syenite, steatite in limestone, tremolite; Drury's Cove, graphite, pyrite, pyrallolite? indurated tale; Quaco, at Lighthouse Point, large bed oxide of manganeso ; Sheldon's Point, actinolite, ashestus, calcite, epidote, malachite, specular iron; Cape Spenser, asbestus, calcite, chlorite, sperular iron (in crystals): Westbearh, at east end on Evans's Farm, chlorite, talc, quetz crystals; half a mile west, chlorite, chalcopyrite, magnesite (vein), magnetite; Point Wolf and Salmon River, asbestus, chlorite, chrysocolla, chalco. pyrite, bornite, pyrite.

Vicmoma Co.--Tabique River. agate, carnelian, jasper; at mouth, south side, galenite ; at mouth of Wapskanegan, gypsum, salt spring; three miles above, stalactites (abundant); Quisalis River, blue phosphate of iron, in clay.

Westmoneland Co.-Bellevue, pyrite; Dorchester, on Taylor's Farm, cannel coal ; clay ironstone ; on Ayres's Farm, asphaltum, petroleum spring ; Grandlance, apatite, selenite (in large crystals); Momrancook, coal (albertite) ; Shediac, four miles up, Scadoue River. coal,

Yonk (o. - Near Frelericton, stibnite, jamesonite, berthierito; Pokiock River, stibnite, tin pyrites? in granite (rare).

## NOVA SCOTIA.

Annapous Co.-Chute's Cove, apophyllite, natrolite ; Gates's Mountain, analcite, magnetite, mcsolite! matrolite, stilbite; Martial's Cove, ancleitc! chabazite, heulandite; Moose River, beds of magnetite; Nictau River, at the Falls, bed of hematite; Paradise River, black tourmaline, smoky quartz!!; Port George, faröelite, laumontite, mesolite, stilbite ; east of Port George, on coast, apophyllite containing gyrolite; Peter's Point, west side of Stonock's Brook, apoplyllitt? calcite, heulandite, launontite! 'abundant), native copper, stilbite; St. Croix's ('ovi, chabazite, heulandite.

Colchester ( 0 - Five Islands, East River, barite! calcite, dolomite (ankerite), liematite, chalcopyrite; Indian Point, malachite, magnetite, red copper, tetrahedrite; limnacle lslands, anuleite, calcite, chetbazite! natrolite, siliceous sinter ; Londondrery, on branch of Great Village River, butitr, ankerite, hematite, limonite, magnetite; Cook's Brook, ankerite, homatite: Martin's Brook, hematite, limonite; at Folly River, below Falls, ankerito, prite ; on high land, cast of river, ankerite, hematite, limonite; on Archibald's land, ankerite, barite, hematite; Salmon River, sonth branch of, chatcopyrite, hrmatite; Shubenacadie River, anhylrite, calcite, berrite, hematite, oxide of manganese ; at the (:anal, lyrite ; Stewiacke River, barite (in limestone).

Cumbermand ('s)-('ape Chiegnecto, barite ; ('ape d'Or, amalcite, aquphollite!! chabazite, faröelite, lammontite, mexodite, malachite, mettodite, uertion enpper, obsidian, red copler (rare), vivianite (rare); Horse fhoe Cove, east side of Cape d'Or, analcite, calcito, stilbite Iske Haute, sonth side, analcite, "pophyllite!! calcite, hombudite!! natrolite, mesolite, stillith!' Jogrins, coal, hematite, limonite; malachite and tetrahedrite at Neaman's Brook; Partridge Ishand, analcite, ('pophyllite! (rare), cmethyst! agate, apatite (rare), colcite!!' chabrazito (acadialite), chabcedony, cat's rye (rare), gypsum, hematite, hembenate! magnetite, stillite!!'; Swan's Creek, west side, near the Point, calcite, grysum, Juchloudite, pyrite; cast side, at Wasson's Blaff and vicinity, auctrite !! apophyllite! (rare), colcite, chabazile!! (acadralitr), g.0 pum, hembutite!! natrolit, ! siliceous sinter; Two lslands, moss asrate, analcite, calcite, chabazite, houlemdit, ; McKay's Ilead, analcite, calcite, heulandite, silicons sinter!

Digibx Co. - Briar Island, native copper in trap; Dighy Neck, Sandy Cove and vicinity, a!ute. amethyst, calcile, chetbaite, hemutite! lamontite (abundant), magnetite, stillite, quartz crystals; dulliver's Hole, matmotite, stilbite! ; Mink (ove, amethyst, chabazit!! quartz erystals; Nichols Mountain, south side, amethyst, matgutite!; Williams Brook, near source, chobazite (green), heulandite, stillite, quartz crystal.

Guysmoro' Co.-C'ape ('anseau, andalusite.
Maimfax Co.-Gay's River, qualenite in limestone; southwest of Halifax, garnet, staurolite, tourmaline: Tangier, gold! in quartz veins in clay slate, associated with auriforous pyrite, galenite, hematite, arsenopyrite, and magnetite; gold at Comutry liarbor, Fort Clarence, Isaac's Marbor, Indian Marbor, Laidlow's Farm, lawrenectown, Sherbrooke, Salmon River, Wine Covo, and other places.

Hants Co.-Cheverie, oxide of manganese (in limestone) ; Petite

River, gypsum, oxide of mancanese ; Windsor, calcite, rryptomorphito (baronatrocalcite), howlite, glauber salt. The last three minerals are found in beds of gypsum.

Kintis Co.-Black Rock, eentrallassite, cerinite ; cranolite ; a few miles east of Black lack, prehnite? stillite?'; (ape. Blomidon, on the coast between the cape and cape Split, the following minerals occur in many places (some of the best localities are nearly opposite Cape Sharp): (thalcits!! ugat!, cmethyst! apophyllite! calcite, chalcedony, chabazite, gmclinite (lederite), hematite, heulandite! laumontite, magwetite, malarhite, mesolitc, native copper (rare), nutroliti! psilumelane, stillitt! thomsonite, faröelite, quatz; North Mountains, mucthyst, bloodstome (rare), ferrufinuus quartz, mesolite (in soil); Long Point, five miles west of Black Rock, heulandite, laumontite!! rtilbite!!; Morden, apophyllite, momrdeutt"; Srott's Bay, aydte, amethyst, chatchdmy, mesolite, natrolite; Woodworth's Cove, a few milus west of Scott's Bay, ryatc! rhalcodony! jusy $r$.
henenberci Co -Chester, dold River, gold in quartz, prrite, mispickel; Cape la Have, pyrite; The "Ovens," ymele, pritio, areenopyrite ; Petite liver, gold in slate
 Hill, six miles west of Fictou. harite; on Carribou Miver, gray eoper and malachite in lignite ; at Albion mines, coul, limonte ; Last liver, limonite.

Quedx's ('o.-Westfeld, gold in guntz prite, arsemeprite; Five livers. near Big Fall, gold in quartz, pyrite, arsenopyrite limnite.

Rirmmond (\%. - West of Plaistior Cove, barite and calcite in sandstone: neurer the (bore, calcite. flumite (blue), siderite.
shelbtene (o.- Shelburme, mear mouth of harbor. garmets (in greciss) ; near the town. rowe quartz; at Jordan and Sahle liver, staurulite (abundant), schiller rpar.

Sydney (o.-Hills east of Lochaber Lake, pryite, chalcopyrite, sidorite, hematite ; Morristown, ppidote in trap. gypunn.

Yaknoteth 'o.-Cream Pot, above (rankery Hill, gold in quartz, byrite; Cat Rock, Fouchu Point, asbestus, calcite.

## NEWFOTNDLAND.

[^6]
## BRITISII COLUMBLA

Carmoo Drstrict.-Native gold, galena.
On Frazer liver.-Gold, argentiferous tetrahedrite, efrargyrite, cinnabar.

Ominica District.-Native grold, argentiferous gralenite, natime silver, silver-amalgam.

Howe's Sounl --Bernite, molybdenite, mica.
Texada Id.--Magnetite.

## II. BRIEF NOTICE OF FOREIGN MINING REGIONS.

The geographical positions of the different mining regions are learned with difficulty from the seatered notiees in the course of a mineralogical treatise. A genmal review of the more important is therefor" here wiven, to be used in comnection with a good mup.

A course aeross Europe, from southeast to morthurest, passea over a large part of the mining rewions, and it will be fomed most convenient to the memory to mention them in this order, commencing with the borders of Turlay.

1. The minem if the Bannat in Southern Inungary. near the borders of Turk'y (about Iatitute 45 , situated proncipally at Orawitzu, Saszka, Dognaska, and Mohdawa: argentiferous copper ores, chalcocite. matachite. copprer prites, caprite, galeuite, ores of zince, enbalt, native gold ; yielding silver, gold, copper, and lead, rocli: syes; te, and granular limestome.
2. The mines of Western Transylvania, about latitudn 4n', situated betwren the rivers Marns and Aranyos, at Nagyag, Offrnbanya, Salathma, and Vorispatak: native gold, telluric gold, telluric silver, white tellarium, with galenite, bleude, orpiment, realgar, stibnite, tetrahedrite, rhodochrosite or carbonate of manganese, manganblende; especially raluable in gold and silyer.
3. In the mountain rance, bounding Transylvania on the north, abont latitude 4 4 40 , nt Nagybanya, Folsobanya, und Kapuik: native gold, red silver, argentiferous tetrahedrite, fhaleony rite or pyritons copper, houde, reagar, stibuite or gray antimony; ror forphyry.
$\dot{4}$. In the Königsberg Mountains, Northern Mungary, a itudo $484)^{\prime}$, at Schemuitz and Fremonitz: argentifrous male 1 ehalcoprrite, nativegold, red silver ore, stilmite, some ce:br ad bismuth, arsenopyrite or mispickel ; particularly valual old, silvor and antimony ; rock: diorite and porphyry.
4. To the east of the Kimigsberg Monntains, at S (huw mitz and Retzhanya: chalcoprrite, tetrahedrits, bleude, stibnite; particularly valuable for copuer ; rock: clay slate.
5. Illyria, west of Ifungary, at IBeiberg and Raibel (in Carinthia): argentiferous galenite, calanime, with some chalcopyrito and othor ores, affording silver and zinc abundautly ; rocl: : mountain limestone. - Also at Idria, native mercury and cinnabar, in argillaceous schist.
6. In Western Styria, at Schladming: arsenical nickel, copper nickel, native arsenic, arsenical iron, largely worked for nickel ; ruck: argillaceous slate. Illyria and Styria are noted also for their iron ores, especially siderite or spathic iron.
7. In the Tyrol, at Zell : argentiferous copper and iron ores, auriferous pyrite, native gold; rock: argillaceous slate.
8. In the Eragebirge separating Bohemia from Saxony, and consisting principally of gueiss :
A. Bohemiau or wouthern slope, at Joachimsthal, Mies, Schlackenwald, Zannwald, Bleistadt, Przibram, Katherinemberg: tin ores, argentiferous galenite (worked principally for silver), arsenical cobalt ores, copper nickel ; affording tin, silver, cobalt, nickel and arsenic.
B. Saxou or northern slope', at Altenberg, Gever, Maricnberg, Annaberg, Scherberg, Ehrenfiedersdorf, Johanngeorgenstadt, Freiberg: argentiferous galenite (worked only for silver), tin ore, various cobalt and nickel ores, vitreous and pyritous copper ; affording silver, tin, colalt, nickel, bismath, and copprer.
9. In Silesia, in the Riescugehirge, an castern extension of the Erzgehirge, at Kupferburg, Jauer, Recichenstein: ores of conper, cobalt, uftording copper, colalt, arsenic and sulphar.
10. In silesia, in the low country east of the Riespngebirge, near the boundary of Poland, at Taroowitz : calamine, suithsonite, blende, argentiferous galenite; affording zinc, silver and lead ; rock: moun tain limestone.
11. Northwest of Saxony, near latitude 51' 30 ', at Fisleben, (Gerlstadt. Sangerhausen, and Mansfeld: tefrahedrite, somewhat arge ntiferous, bornite or variegated copper ore, affording eopper ; poch: a marly bituminuas schist (kupferschiefer) more recent than the (arboniferous strata.
12. In the Maragelirge (Martz Mountains), north of west from Fisletem, about latitude 51 co , at (lanshad, Zellerfekd, Lauthenthal, Wildemann, Grund, Andreaherg, Goslar, Lanterberes: chaleocite or ritreous copper, tetrahodrite, chaleopyite, cobalt ores, copper nickel, ruby silver ore, argentiferous galenite. blende, antimotiy ores; affordiug silyer lead, copper, and some gold
13. In Messe-(assel, to the southwe:t of the Martz, at Riechelsiforf: arsenical cobalt, arsenical nickel, nickel uchre, natire lismuth, bismathinito, galenite, affording cobalt ; ronk: red sandstome. Also at Borber, cobalt ores in mica slate.
14. In the Bavarian or IPper Phine (Palatinate), near latitude $49^{3}$ 4.'. at Landsberg near Moschel, Wolfstein, and Morsfeld : chmabar, native mercury, amalyam, horu quicksilver, pyrite, some tetrahedrite, and chalcoprerite ; probis: coal formation
15. Province of the Low r Rhine, at Altonberg, near Aix la Chapelle (wr Aachen): ealamine, smithsonite, galenite, affording zinc; rock: limestone. The same just south in Netherlands, at Limburg, and also tw the west at Vedrin, near Namur.
16. There are also copper mines at Saalfold, west of Saxony, in fimon-Meiningen, in Southern Westphalia near Siegen, in Nassau at Dillenbers, and elsewhere.
17. In Switzerland, at Canton du Valais: argentiferous galenite, and valuable nickel and cobalt res.
18. The range of the ' o:ges parallel with the lhine, about St

Mare-aux-Mines: argentiferous galenite (atrording 1-1000 of silver), with pypomorphites, tetrahedrite, antimonial salphuret of silver, na-. tive silver, arsenical cobalt, native arsenic, and pyrite, occasionally auriferous; affording silver and lead; rocks: argillaceous schist, sycnyte, and porphyry.
20. In lranco there aro also the mining districts of the Alps, Auvergne or the Plateau of Central France, Brittany, and the l'yrenees, but none aro very productive, except in iron ores. Brittany roscmhles Cornwall, and formerly yielded some tin and ropper. The valley of Oisans in the Alps, at Allemont, contains argentiferous galenite, arsenical cobalt and nickel, gray coppre, native mercury, and other ores, in talcose, micaceous, and syenytic sehists, but they are not now explored. The region of ('entral Fravee is worked at this time only at Pont(iibaud, in the department of Puy-de-Dome, and at Vialas and Villefort in the (tard. The former is a region of schistose and granite rocks, intersected by porphyry, uffording some copper, antimony, lead, and silver; the latter of guriss, affording lead and silver, from argentiferons ghlena. The French l'yrenees are worked at the present time only for iron.

21 . In Encland there are two great motalliferous districts :
A. On the southwest, in Cornwall, and the adjoining county of Deronshire : pyritous copper and various other eopper ores, tin ores, Galenite, whith some bismuth, colalt, nirkel and antimony ores ; affording principally copper, tin, and lead; rocks: granite, smeiss, micacoous and argillacoms schist, elvanyte.

B On the borth, is C'umberland, the adjoining parts of Durham, with York-hite and Derbyshire, just south : galenite, and other lead owes, bende, copper ores, celamine and smithsonite (the zinc ores especially at Alatonmoor in C'umberland, and ('ustleton nud Matherk, in Berbyinim, aftording some zine, and three-fifthe of the lead of Gecat Britain, and some ropper; jork: (arloniforous limestone.
(. There is also a vein of calamine, blende, and galenite, in the same limestone at Holywell, in Flintshire, on the north of Wales; another of calumine at Mendip Hills. in Southern England, south of thas Bristol (hannel, in Somersetshire, occurring in magnesim lime. ftone; mines of colper on the Iste of Angleser, in North Wales, in Westmoreland and the adjacent parts of C'umberland and Lancashire, in the southwest of Scotland, tho Isle ol Man, and at Ecton instaffordshire, de.
22. In Spain there aro mines-
A. On the :onth, in the mountains near the Mediserranean coast, in New Grenada, and cast to Carthagena, in Murcia; also in New Grenada, in the Sierra Nevada, or the mountains of Alpujarras, the Bierra Almaprera, the Nierra de Gador, just hack of Almeria, and at Almazarron near Carthagena: galmite, which is argeniferous at the Sierra Almagrera and at Almazarron, affording full 1 per cent. of silver ; rock: limestone, associated with sehist and crystalline rocks.
B. The vicinity of the range of mountains ruming westward from Alcaraz (to the district of La Mancha), to Portagal. 1. On the sonth, near the centre of the province of Jaen, at Linares, laditude ' $33^{\prime} 5$ ', longitude os $40^{\prime}$ : galenite, cerussite, cuprite, malachite, in granite and schists; affording lead and copper. $\underset{\sim}{2}$. In La Mancha, at Alcaraz, northeast of Linares, latitude $35^{\prime \prime} 45^{\prime}$ : calamine affording abundantly
zinc. 3 . In the west oxtremity of La Mancha, near latitude $38^{\circ} 38^{\prime}$, at Almaden: cinnabar, native mercury, pyrite, in clay slate. 4. Southwest of Almaden, in Southern Estremudura, and Northwestern Seville: tetrahedrite; at Guadalcanal, Cazalla, Rio 'Jinto: chalcanthite or copper vitriol, malachite, with some red silver ere, and native silver, in schists or limestones.

There are also mines of lead and copper at Falsete in Catalonia; in Gadicia, a little tin ore ; in the Asturias at Cabrales, copper ores.
23. In Sweden: 1. At Fahlun, in Dalecarlia: chaleopyrite, bornite ; rock, semyte and schists. At Finbo and Broddbo: tantalum ores, in ore. At Aala: argentiferous galenite, affording lead and silver ; rock, ceystaline limestone. At Vona (or Wehna) and at Tunaberg: arsenical cobalt, erythrite; roek, mica slate and gneiss. At Dannemora aud alsewhere: magnetic iron ore or magnetite.
24. In Norway, at Kongsberg : argentite or vitreous silver, native silver, horn silver, native gold, gralenite, native arsenic, hende ; rock, mica slate. At Nodum and Skutterud: colnalt ores, native silver; rows, mica slate. At Arcudal, magnetic iron ore.
25. In lussia:-In the Vrals (nostly on the Asiutic side), at Ekatherinenbere, Beresof, Nischme Tarilsk, cte.: native gold, plati. nom, iridium, native reppr, ruprite, matarhite. 2. The Atai (Southem Siberia, at Kolyvan and Kmeof : native qohd, native silver, argutiferons galema, crussite, nation ropper, oxides of copper, malschote, chaleoprite: forks, metanorphir 'wds and porphry. 3. In the Davuria Momitains, east of Lake Baikal, at Nertchinsk : argentiferons galenite, cerussite, mimetito, gray antimony, apmonyrite, calamine, cinnatur ; rocks, compact limestone and sichists
20. In Australia:--In southern Queensland, and the northern part of New South Wales, or the New England district : tin ore or cassiterite abundant, with also native gold. In New South Wales, along the Blue Mountains and the continuation of the range parallel with the coast north and south, in the Bathurst, Mudere, Lachlan and other districts: native gold, chaleopyrits, some cimabar. In Victoria: native gold In South Australia, especially at the Burra, Wallaroo, and Moonta mines: copper ores

Other fortign mining regions are the copper mines of Cuba, and South America; the silver miness of Chili, Bolivia, Peru in South America, and of Mesico; the gold mines of South America, especially those of Brazil, South Africa, and of the Philippines, Borueo, New Guinea, New Caledonia, and New Zealand in Australasia; the quicksilver mines of Huanca Velica, Peru, and those of China; tho tin mines of Malacea (principally on the ishand of Junk-(ceylon), and of the island of Banco between Borneo and Sumatra; of zince, in 'hlina; of platinum, in Brazil, Colombia, St. Domingo, and Borneo) of palladium, in Brazil ; of arsenic in Khordistan, Turkey in Asia, and also in China; of nickel, in New Caledonia.

## IV. DETERMINATION OF MINERALS.

In the determination of mincrals, no one order in the suceessom in which characters should be examined answers for all minerals, or even for all of the same section of spectes.
A. For spories haring a motalle lustre:
(infor will be first noted ; and thern strent-that is, the rotor of the mineral on a surface scratehed or abraded hy a fine file, or when arey finely powdered, and the bustre of the powder or abmad surface, whether motallic like the mincral or ummetallic. Harduess whold be aseertaned when ohtaining the strak.

Jionefiner and chemicell charusters are of the highest value, giving enderally the most certain results.
 ing a medallic lusim, sime the differences in density among such apecies are winally large. *

Coystalline fonm and whentere are of first importance, whenerer the sperimen allows of their determinathen.
13. For species without metallic lustre:

Streth: is sometimes of importance, equecially amomg sjercies in which it is highly colored.
(oulor is gencrally of litale value owing to the variations that fremuently come in through impurities.

Lustre is one of the first characters the ere will onserve, hat its variaion mater most epecess is wide, and often it is of little value. State of atefrequation and fracture for the most part serve to distinguish ouly varienes.

Intromes is abod often a varying chamacter, the rane under some arecies being from 1 to 6 in the seale of hartness ; and still its indications are generally inportant.
('rystalline form and clearege are always important when olservable.

[^7]Traste is of limited value, as few minerals are sufficiently soluble ; but among soluble minerals it is casily obserred, and often decisive.

Action of tride, cold or hot, in trials as to effervescence, solubility, gelatinizing or not, and in making solutions for examination with other reagents, is a very important means of distinguishing species.

Bloupipe reuctions are easily obtained, and of the highest value.

Sperific aravity is an important reliance.
laffuction and pulariation afford valuable criteria for distinguishing species, and in a few eases no other means are so reliable short of chemical amalysis.

The following hints may be of servire to the beginner in the seience, hy enabling him to orereome a ditlienty in the outeret, arising from the varoms forms and apperance of the minerals quartz and limestone. Quartz oceurs of nearly every color, and of rarious degrees of glasy hastre to a dull stone without the slightest glisteniug. The common grayish cobble-stones of the fields are usually quartz, amd others are dull red and brown from these there are gradual transithons to the pellued yuare erystal that looks hke the hest of glass. Nadstoncs and freestones are often wholly gatartz, and the seashore sands are mostly of the same material. It is therefore probable that this mineral will be often encountered in mineralonical rambles. Lact the first trial of specimens obtained be made with a file, or the point of a knife, or some other means of trying the hardness ; if the file makes no impression, there is reason to suspect the mineral to br gnartz ; and if on hraking it, no reqular structure or clearage plane is olsored, but it breaks in all directions, with a similar surface and a more or less vitreous hastre, the promability is murh strengthened that thes conclasion is correct. The blowpipe maty next be used; and if there is no fusion produced by it in a carcful trial there can be little doubt that the specimen is in fact quartz.

Calcite (calcium carbonate), inclurding limestone, is another very common species. If the mineral collected is rather easily impressible with a file, it may be of this spe"隹; if it rffervesces freely when placed in a test-tube contaming dilute hydrochloric acid, and is finally dissolved, the probability of its being carbonate of lime is increased; if
the blowpipe produces no trace of fusion, but a brilliant light from the fragment before it, but hatle doubt remains on this point. Crystalline fragments of calcite break with three equal ohligue cleavages.

Familiarized with these two Protem minerals by the trials here alluded to, the student has already sumounted the principal difficulties in the way of future progress. Freguently the young, begimer, who has devoted some time to collecting all the difterent colored stones in his neighborhood, on presenting them for mames to some practised mineralogist, is a little disappointed to learn that, with two or three exceptions, his large varicty includes nothing but limestone and quartz. He is perhaps gratitied, howerer, at being told that he may call this specmen yellow jasper, that red jasper, another flint, and another hornstonc, others chort, gramular quartz, ferrugmons guartz, chalcedomy, prase, smoky quartz. greasy quartz, milky quarta, agate, pasma, hyaline puartz, quartz crystal, batanite, radated dumetz, tabular cuarta, ete., cte.; and it is often the case, in this state of his knowledge, that he is best pheased with some treatise on the stience in which all these barions stones are treated with as much prominence as if actually distinct species; being loth to receive the unweleome truth, that his whole extensive cabinet contains only one mineral. But the mineralogial student has alroudy made good progres when this trath is freely admitted, and 'quarts amd limestone, in all their varietico, have become known to him.

The student should be fimiliar with the use of the blowpipe and the reactions, as explained on pages 80 and 85 : and it would be still better if a fuller treatise on the subject had been carefally studied. He shond be supplied with the three acids in ghas-stoppered bottles ; a fourth botole containing hydrochloric aced diluted one-half with water, for obtaining efferrescence with carbonates; test tubes; and also the ordinary blowpipe apparatus and tests, inchudine platinum wire, phatimm forecps, glass tube, "cobalb, solution." litmus and turmeric paper, ete.

Also the following:
A smatl file, three-cornered or flat, for testing harlness.
A knife with a pointed blade of gool steel, for trying hardness. It may be magnetized, to be used as a magnet, though a good horseshoe magnet of small size is betier.

Tho series of crystallized mincrals, constituting th of hardness (see page (i3). Diamond and tale are least essential.

Cutting pliers, for removing chips of a mineral for blowpipe or chemical assay.

A porket-lens.
A hammer weighing about two pounds, resembling a stone-cutter:s hammer, having is
 flat face, and at the opposite and an edge having the same direction as the handle. The handle should be made of the best hickory, and the mortise to receive it should he as large as the handle. A foot, wrale should be marked on the handle of the hammer. divided into inches, the smallest divisions neded. It will be oftem of use in geting out a yard-stick, or a ten-foot pole, for large measurements. A similar hammer, having the upper part prolonged to a blunt point, to be used like a pick, is often conrenient.

A hammer of half a pound weight, like the fignee, to be used in trimming specimens.

A small jeweler's hammer, for trying the mallealnlity of globules oltained by the howpipe, and for other purposes, and a small piece of steel for an amvil.

Two sted chisels, one siv inches long, and the other three. When it is desired to pry open scams in rocks with the larger chisel, two pieces of sted phate should be provided to plate on opposite sides of the chisel, after an opening is obtained; this protects the chisel and diminishes friction while driving it.

For blating, if this is desired :
Three hand-drills 18 , "4, and 36 inches long, an inch in diameter. The best form is a square bar of steel, with a diagonal edge at one end. The three are designed to follow one another.

A sledge-hammer of six or cight pounds weight, to use in driving the drill.

A sledge-hammer of ten or twelve poonds weight, for breaking up the hasted rock.

A round iron spoon, at the end of a wire fiftem or cighteen inches long, for removing the pulverized rock from the drill-hole.

A crowhar, a pickaxe, and a hoe, for removing stones and earth before or after blasting.

Cartridges of hasting powder, to use in wet holes. They should one-third fill the drill-hole. After the charge is put in, the hole should be filled with sand and gravel alone without ramming. If any ramming material is used, phaster of Paris is the best, which has been wet and afterwards seraped to a powder.

Patent fuse for slow match, to be inserted in the cartridge, and to lead ont of the drill-hole.

The table beyond is prepared especially to aid in instruetion, and comprises, with few excephions, only the suecies that are dencribed in large ty fe throngh the work, exclusive of the hydrocarbon componinds. The following abbreviations are used in it, in addition to those explamed on page 90. With reference to colors: bnh, brownish; bkh, blackish; gnh, greenish; gyh, grayish; relh, reddish. 'The acids: nit., nitric acid ; sulph. aciel, sulphurie acid ; H1 ' \%., nydrocloric arid : vulph., sulphurous or sulphurous acid.

Reactions: ! d datinizing with atid, veo page 81 ; raction for sulphtur aith seder, sce page 89 ; blue or red color with cobult solution, see page 88 ; hydrous, yichding water in a closed tuhe ; anhyifrous, not yiciding water in a clased tube, or only traces, see page 86; B.13. lithium-red rolor, see page s\%; li.li. yrem flame due to buron, see jage sir ; roul is used for charcoal; jus. for fusible; infus. for infusible; sol. for soluhte; st. for streak.

In using the bowpipe it is important to remember that, a trial of fusibility with the forceps, if not at onee producing fusion, should be made on a piece of the mineral not, larger than the fourth of an ordinarypin-head, and it should be either oblong and slender, or ihin, and be made to project considerably beyond the peints of the foreeps, lest the foreeps carry off the heat, and canse a failure where there ought to be suceess. Further, it should be in mind, that in using charcoal, a white coating is always a consequence of burning it, since the ath from its own combustion is white. Again, before testing for sulphur by means of soda and a polished surface of silver, it is necessary to try the flame and the soda for sulphur. Gas-flame always contains traces of sulphur, and sometimes too much for safo conclusions in this trial.

A mineralogist sometimes has accasion to mesure distances, and by the following method he may make 'imself quito an accurate odometer:

Let him first timd, or make, along a roadside, a measured distance of soo to $]$,000 fert, and then walk it at his ordinary walking pace thre or four times, and note the number of steps. He will thas ascertain the actual length of his pace, and also find that in his ordinary walk it does not differ much from thirty inches; it may be an jach or twe: lems, or one, two or three more than this. Now four timese thiriy inches is ten feet. If them, as he walks, he como e one for every fourth step, cach mit in the comet will stan, ne for ten feet nearly, and 100 , for 1,000 fect nearly. If 1 to pace is thirty-one inchos, let hion add a mit for areate thirty in the counting, or, which is the same thing, call hasd thirty thirty-one, and the needed correction will he made; ? or if his step is twenty-nine and one-half inches, subtract one from every sixty in the counting, or in other words duplicate the sisty. Or the correction may be mate at the end of the pacing ; if at (oro, this number, after adding a thirtieth, beomes 620 : and the distance would hence be 6,200 fect. With a little practice the comoting may be carried on almost unconseiously, and when the thoughts are elsewhere ; that is, unless there is a talking friend by ones side.

An instrument, callerl a pertomeler, of the shape and sizo of a small wateh, is to be had of instrument makers, which, if carried in the waisteoat pocket, will do the registering for the pedestrian and note the distance, without any attention on his part. But the odometer explained abore, when once in working order, is always at hamd.

## SYNOPSIS OF TIIE ARRANGEYENT.

## I. ELEMENTS.

1. Justre metallie ; liquid.
2. Lustre metallic; malleable and eminently sectile.
3. Lustre metallic ; brittle ; B.B. on coal, wholly volatile, with no sulphurous fumes
4. Lustre metallic; brittle ; $\mathrm{H}=1-2$; leaves a trace on paper ; 3.13. on coal, infusible, no fumes or odor.
5. Tnmetallic ; burns readily with a blue flame.
6. Lustre adamantine ; $\mathrm{H}=10$.

## II. MINERALS NOT ELEMENTS, TIIAT B.B. ON COAL ARE WHOLIY VOLATILE.

1. Lastre metallic ; streak metallic.
2. lustre unmetallic ; streak same as color.
III. (OMPOUNDS, OF GOLD, STMVER, COPPER, LEAD, TIN, MERCUKY, CHROMIUM, ('OBAL'T, MAN(ANESE : yielding, on heating, a malleable, or liguid (for moreury ores), metallic globule, as explained on pages 389-393, or else affording a decisive howpipe reaction, proving the presence of one or more of these metals.
A. Yielding a malleable globule B.B. on coal with, if not without, soda.
3. ('omprunds of Gold.
4. Compounds of Silver.
5. Compounds of Copper.
6. Compounds of Lead.
7. Compounds of Tin.
8. Yielding drops of mercury with soda in a olosed tube.
9. Compounds of Mercury.
C. A decisive raction with borax or salt of phosphorus for chromium, colalt, or manganese.
10. Compounds of Cliromium.
11. Compounds of Cobalt.
12. Compounds of Mayganese.

## IV. MINERALS OF METALLIC OR SUBMETALLIC LUSTRE, NOT INCLUDED IN PREGEDIN(: IIVISIONS.

1. Yielding fumes in the open tube or on coal, but not wholly vaporizable.
A. Streak metallic.
B. Streak unmetallic.
n. Fumes sulphurous only.
b. Fumes arsenical, with or without sulphurous.
2. Not yiolding fumes of any kind; streak ummetallie.
A. B.B. easily fusible, giving a magnetic bead; lustre submetallic.
B. Infusible, or nearly so.
a. Reaction for iron; anhydrous.
b. Reaction for iron; hydrous.
c. Reaction for chrominu or titanium.
d. Reaction for osmium with mitro.

## V. MINERALS OF UNMETALLIC IUSTREE.

1. Maring an acid, alkaline, alum-like, or styptic taste.
A. CARBONATES - Taste alkaline ; ffervescing with IIC].
2. SCLPHATES: No effervescenco ; reaction for sulphur with soda.
C. NITRATES' With sulph. acid, reddish acrid funcs; no action with HCT ; deflagate.
D. CILORIDES: With sulph acid, acrid fames of HC'l, no fumes with IICl.
E. BORATES : No effrrvescenee; reaction for boron when mostened with sulph. acid.
3. Not having cither of the abovementioned himts of taste.
A. CARBONATES : Efferreacing with HCl.
". Infusible; assay alkaline after imuition.
b. Infusible; become magnctic and not alkatins, on ignition.
c. Infusible; B.B. on conl with sodn, riue oxido vapors.
a. Infucible ; B.B. on coal reaction for nickel.
e. Fusible ; assay alkatine after ieruition.
B. SULPHATES : Reaction for sulphur with soda
a. Fusible; assay alkalme after fusion.
b. Fusible; reaction for iron.
c. Infusiblo.
C. ARSENATES : on coal arsenical fumes.
D. SHLICATES, PHOSPHATES, OXIDES:

Species not included in the preceding subdivisions.
I. GTREAK DEEP RED, YELLOW, BROWNIBI-YELLOW, GREEN, OR BLACK.
A. Infusible, or fusible with difficulty.
B. Fusible without much difficulty.
II. STREAK GRAYISII OR NOT COLORED.

## 1. Infusible.

A. Gelatinize with acid, forming a stiff jelly.

13 Not forming a stiff jelly ; hyirous.
a. Blue color with cobalt solation.
b. Reddish or pink color with cobalt solution.
c. Not blue or red with cobalt solution.
C. Not forming a stiff jelly ; anliydrous.
a. Phe color with coinalt solution.
b. Noe blue or reddish color with cobalt solution.

## 2. Fusible with more or less difficulty.

A. Gelatinize and form a stiff jelly.
a. Hydrons: face easily.
b. Hydrons ; fuse with much difliculty.
c. Anhydrous.
$\alpha_{\text {, No }}$ Notion for sulphur; no coating on coal.
$\beta$. Reaction for sulphur with soda.
B. Not gelatimizing.

1. Structure eminently micaceous; folia tough, pearly, and II. of surface of folia not over 35 ; anlyydrous or hydrous.
2. Structure not eminently micacoous. a. Hydrous.
$\alpha$. No reaction for phosphorns, or boron.
f. II. =1 to 8 ; lastre uot al all vitreous.
+†. H. $=3 \cdot 5-6$ : lastre of cleavage surface sometimes pearly ; elsewhere vitreous.
(3. Reaction for phosphorus wi horon.
b. Anhydrous
a. iB B . lithium-red flame

乃. B.B boron reaction (ereen Alame).
$\gamma$. B. B. reaction for titaniva.
ס. B B. reaction for thorine or phosphorus.
ع. B.B. reaction for irom.
y. B. B. no reartion for iron: not of the preceding subdivisions.

## I. ELEMENTS.

1. Lustre metallic; liquid.

MERCURY, p. 128. This is the only metallic mineral which is liquid at the ordinary temperature and atmospheric pressure.
2. Lustre metallic : malleable and eminently sectile.

GOLD, p. 109. G. $-15-195$; yellow ; fusible; not sol. in nitric acid or HCl , but sol. in agua regia.
PLATINUM, p. 1:4. $\quad \mathbf{G} .=16-19$; nearly white; infusille; insol. in nitric acid.
PALLADIUM, p. 127. G. $=11 \cdot 3-11 \cdot 8$; grayish-white ; diff. fusihle ; sol. in nitric acid.
SILVER, $p$ 116. $\mathrm{G} .=10-11 \cdot 1$; white; fusible; sol. in nitric acid, and deposited ugain on copper.
COPPER, p. 1:1. (i $=8.84$; copper-red; fus.; sol. in nitric acid, and the solution becomes sky-blue when ammonia is added
IRON, p. 1\%1. $\quad$ i. $=7 \cdot 3 \cdot 7 \cdot 8$; iron-gray; attructed by the magnet.
The only other mineral of metallic lustre that is also malleable and eminently sectile is argentite, a silver sulphide, along with two others of like composition but different crystallization.
3. Lustre metallie; brittle; B.B. wholly volatile, but give off no sulphurous fumes.

BISMUTH, p. 101. $\mathrm{Q}=973$; reddish-white ; on coal a yollow coating ; fumes inol.
ANTIMONY, $100 \quad(\mathrm{G}=66-6 \%$; tin-white ; fumes dense wh., inod.
ARSENIC, p.98. G. $=59-(i ;$ tin-white; fumes white, alliaceous.
TELLURIUM, p. $96 . \mathrm{G}=6 \cdot 1-63$; tin-white ; fus.; fumes white ; flame green.
The only other mineral that is wholly volatile, and also gives off no sulphurous fumes, is allemontite, an antimony arseuide.
4. Lustre metallic ; H. $=1-2$; B.B. on coal infusible ; no fumes.

GRAPHITE, p. 107.
5. Lustre unmetallic; takes fire readily in the flame of a candle, and burns with a blue flame.
SULPHUR, p. 94.

## 6. Lustre adamantine ; H. $=10$.

DIAMOND, p. 103. Easily scratches corundum or sapphire.

## II. MINERALS, NOT ELEMENTS, THAT ARE WIIOLLY VOLATILE B.B. ON COAL.

1. Lustre metallic ; streak metallic.

TETRADYMITE, p. 10~. Q. $=7.2-9$; pale steel-gray; so soft as to soil paper ; on coal white fumes; flame bluish-grenn; sometimes sulph. odor ; in open tube, a coating which fuses to white drops.
BISMUTHINITE, p. 10\%. ( $1 .=6 \cdot 4-7 \%$; whitish Jead-gray; on coat yellow coating and sulph. odor.
STIBNITE, P. 100. (i. $=45452$; lead-qray ; on coal dense wh. fumes and wh. coating .
2. Lustre unmetallic; streak same nearly as color.

ORPLMENT, p. 99. Iemon yellow ; on coal burus, ofor alliaccous. REALGAR, p. 90. Broght rid; on coal burns, ddor allacrous.
ARSENOLITE, p 99 White; on coal, whor alliaceous.
VALENTINITE, 1 , 101 White: on coal dense wh. fumps, innd.
CINNABAR, 1. l只s. Ked; in open tube, suljh. odor, coating of mercury equblos.
SALIMIAK, 1 . 230 . White ; saline and pungent taste ; on coal, fumes of ammonia.

## III. COMPOUNDS OF GOLD, SILVER, MERCURY, COPPER, LEAD), TIN, CHRO. MUM, COBALT, MAN(ANESE.

A. Yielding a malleable globule 13.13. on coal, with or without soda.

## 1. COMPOUNDS OF GOLD.

Yield gold, or an alloy of gold and silver, B B on coal. The telduPIOM ORES, pp. 115, 116 , give a coating of drops of tellurous acid in open tube。

## 2. COMPOUNDS OF SULVER.

B.B. easily fusible ; a above 5 ; yield, with few exerptions, a globule of silver (white and malleable), on coal, with soda, if not without; and, in the exceptions, silver gholmale oltained by cupellation. All have metallic lustre excepting cerargyrite. bromyrite, and iodyrite.

## a. EMINENTLY EE(TILE.

ARGENTTTE, p. 117. G. $=7 \cdot 7 \cdot 7$; lustro metallic ; on coal sulph. fumes.
CERARGYRITE, p. 120. G. $=5 \cdot 5-56$; lustre like that of white, gray, or greenish to brownish wax.

## l. not sectile ; on coal odonouts fumes.

SULPHIDES, p. 118 . Gives sulph odor.
ARSENICAL ORES, pp. 119, $1 \geqslant 0$. Alliaceous fumes.
SELENIDES, p. 118. Horse-radish odor.
c. NOT SECTILE ; ON COAL FLMES OF ANTIMONY OR TELLLERIUM.

ANTIMONIAL ORES, pp. 119, 120. Dense white fumes of antimony: with also, if sulphur is present, sulph. fumes.
TELLURIDES, $p$. 118. In open tube conting which fuses to drops of tellurous acid.
STROMEYERITE, p. 119. Contains copper and requires cupellation in order to obtain a globale of silver.

## 3. COMPOUNDS OF COPPER.

Unless iron is present. a globule of metallic copper is obtained with soda, if not without, on coal; with a nitric acid solution and ammonia in excess a bright blue color; moistened with IICl the blue flame of chloride of copper; and a clean surface of irou in the nitric solution becomes coated with erper.

## 1. metailic hustre.

SULPHIDES, pp. 132-136. On coal or in open tube sulph. fames. ARSENIDES, SELENIDES, p. 13:.
ANTIMONIAL SULPHIDES, p. 135, 136.
2. lestre enmetallic; b.b. neturith on coal noil in open tebe any odorous flemes; no taste.

CUPRITE, p. 136. I. $=3 \cdot 5-4:$ G. $=5 \cdot 8-6 \cdot 2$; isometric; deep red, streak buh-red.
ATACAMITE, $p$ 136. Darkish bright green, streak prh; 13.B. on conl fuses, coloring O.F. azure-blue, with a green edge ; casily sol. in acids.
PHOSPHATES, $p$. $1: 9$.
MALACHITE, p 140. $\mathrm{H} .=3-4 ; \mathrm{G} .=3 \cdot \pi-4$; light to deep preen, effervesces with HCl.
AZURITE, p. 141. H. $=35-4.5$ G. $=35-3.9$; deep blue; efferveseres with HCl .
DIOPTASE, p. 141. $\mathrm{H}=5$; G. $=325-335$; emerald-green; B.D. iufusible.
CHRYSOCOLLA, p. 142. Bluish green; B.B. infusible.
3. htstme dnmetaimic; b.b. on coal, or in clesed tube, odorou's Fl mes of ansenic or sclipher, on meaction for sulputr.

ARSENATES, p. 139. On conl arsenical fumes.
CHALCANTHITE, 1, 137. Blu*; taste nauserus; astringent. Also Stromeycrite, stannite, Bournonite give reactions for copper.

## 4. COMPOUNDS OF LEAD.

Yichl B. B. on coal a dark lemon-vellow coating ; finally, with soda, if not without, a rlobuls ( netalis: and malleable) of lead is obtained; but by continued blowing with O.F. the lead all goes off in fumes, leaving other more stable metals (silver, ete.) behind. Sulpharous, selenious and tellurous fumes masily obtained cither on coal or in an open tube from the sulphide, sclenide, tellurides: and arsenical or antimonial fumes from ores containing arscinc or antimony. None have taste.

## 1. hyethe met mhatc.

GALENITE, p. 145. II $=25 ;(4=\pi \cdot 0-7 \cdot 7$ cleavaro cubic eminent ; lead-gray, streak same ; in open tube sulph.
SELENIDES, TELLURIDES, ANTIMONIAI RUd ARSEN: ICAL SULPHIDES, page 149.
2. MESTYE TNMETAHft ; NO ODOROTS FTMEW, OR REACTION FOR stifiluti.

MINIUM, p. 149. Briplit red, streak same.
CROCOITE, p. 150. Monselinic ; brieht red, slreak ornuge-ycllow ; B.B. with salt of phosphorus emerald-green bead.

PYROMORPHITE, 1. 151. Hexaronal ; bright green to hrown, rarely orance-yollow ; streak white. B.B. fuses easily, culoring flame blaich-irvern.
CERUSSITE, $1.15 \%$. Trimetric, often in twins; IH. $=3-3 \cdot 5$; G. - $6 \cdot 4-68$; white, gyh; lustre adamantine; often tarnished to grayish metallie adamantine. Efferve:es in dilute nitrie acid.

## UNMETALLIC; REACtion FOR sulphtr.

3 , page 150. Trimetric: ; whitr, gyth; fuses in flame of candle ; B.B. reaction for sulphur ; no efferveseence with acids.

## 5. COMPOUNDS OF TIN.

CASSITERITE, p. 160. I. $=6-7 ; \mathrm{G} .64-7 \cdot 1$; brown, gyh, ywh, black: B.B. infusible; on coal with soda a globule of tin, yield no fumes

Stanuite, p. 158. A copper, iron, and tin sulphide, does not give B.B. a motallic malleable crobule.
B. Yield drops of mercury in closed tube with or without soda.

## COMPOUNDS OF MERCURY.

CINNABAR, p. 128. H. $-2-25 ; \mathrm{G}=8-9$; bright red, buh red, gyh ; streak scarlet.
AMALGAM, p. 117. H. $=: 3-3.5$; $\quad$ ( $=13-1$; ; silver-white ; yields silver B.B. on coal.

Aramiolite', p. 136, a variety of tetrahedrite, yieids mercury.
C. No malleable globule; decisive reaction with borax or salt of phosphorus for chromium, cobalt, or manganese.

## 1. COMPOUNDS OF CHROMIUM.

Give with boras an emerald-grenn bead in both flames.
CHROMITE, p . 100 . II. $=5 \%$; G. $-48.1 \%$ : isometrie, often in octahertons, massive: submetallic; buh ison-hack, streak h,rown ; 13.1 on enal becones magnetif; with boras, a bead which is emerald-green on cooling.
CROCOITE, p. 150 $1 .=25-3 ;$ G -596.1 ; bright red, streak orange ; B.B. fuses very pasily, on coal globule of lead, and with salt of phosphorns emorald-green bead. Phanicuchrote and Vanquelinite are other leal chromates.

## 2. COMPOUNDS OF COBALT

Give a hue color with borax after, if not hefore, rasting.
(When much wickel or iron is present the blue color is not nb). tained; and species or varietios of this kind are not here ineludd.?

## 1. Lektie met ildic.

COBALTTTE, p. 105. H. -55; (1.- 664 ; isometric and pyritohedral ; rehsilver-white, streak grayish-hack; B.B on coal sulph. and arsen. fumes, and a magnctic globule.
 gylh black: B. B. on conl alliaccous fumes ; most warieties fail togive the bloe color immediately with borax, because of the irom and nickel present.
LINNEITES $\mathrm{p} 164 \mathrm{H}=5 \%$ : $\mathbf{Q} .-185$; isometric ; pale strelgray, copper-red tarnish, streak likh gray. B.B. on coal sulph. fumes.

## 2. LUETRE UNMETALLIC.

ERYTHRITE, p 16\%. H. 15-25; Q. -295: monoclinic, one highly perfeet cleavage, also earthy; rose-red, peach-blossom red, strealk reddish; B.B. fuses casily ; yiclds water.

BIEBERITE, p. 168. A cobult sulphate. REMINGTONITE, p. 168 . A hydrous cobalt carbonate.

## 3. COMPOUNDS OF MANGANESE.

Give an amethrstine globulo in O.F with borax. [The globule looks blark if too much of the manganese mineral is used, and with a large excess may be opuque.]

1. GIVEA OFF CARBONIC AcID WHEN TREATEI) WITII DHLCTE IICl; LCETRE UNMETALAIC'.

RHODOCHROSTHE, p. 191. II. $-35-4 j ; ~ G .=34-37$; rose-red.
Also manganose-boaring varicties of calcite, dolomite, ankerite, siderite, all of which have the cleavage and general form of riodochrosite; when containing a few per cent. of manganese they often turn hack on exposure.

## 2. TRE.ATEi) Witil HCl yelis chlomine fumes.

MANGANITE, 1 iK9 HI. $=4$; $(4-42-44$; in obong trimetric prisms; prayinh-hark, streak reduish-brown; lustre submetallie: 13. 3 . infusible ; vimbs water.
 streak brownish black; submetallic ; 13 13. infusible; yirlds water. Wod is similar, but often contains coldalt.
PYROLUSITE, p. $1 \mathrm{NB} \quad$ II $-2-25 ;(\dot{\sim}=4 \times 2$ : in stoutich trimetrie, erystals; metallic: dark steel-gray, streak black or bluish-black; 13.13 infusible ; yields no water.

BRAUNITE and HAUSMANNITE (p. 189) are other anhydrous mangancese oxides.
FRANKLINITE, p. 179. $\mathrm{H}=5 \cdot 5-65$; $\mathrm{G}-5-5 \cdot 1$ : in ortahedrons and massive; iron-black, streak dark reddish brown; B.B. infusible; but little chlorine with IICl.
3. $\mathrm{CO}_{2}$ on Cl not aiven off when treated with HCl ; ANMYDHOUS.

RHODONITE, 1. 217. H. $-5.5-65$; G. $=3.4-368 ;$ rose-rad; B. Г. fuses easily.
TRIPLITE, p. 191. $\Pi .=5 \%$; $\alpha=34-88$; brown to black; B.B. fuses very easily, globule magnetic; sol. in 11 (1.
 hedrons; B.B. fuses casily.
SPESSARTITE (Manganesian Garnet), p. 258. $\quad \mathrm{H}=6.5-7 ; \mathrm{G}=3.7-$ 4.4 ; in dodecahedrons and trapezohedrons; red, brownish-rod; B.B. fuses easily.

TEPHROITE, p . 256. II. $=55-6 ; \mathrm{G}=4-4 \cdot 12$; roddish to brown and gray ; B.B. fuses not very easily ; grelat. in H (1).

Kncbelite, p. 250, is related, and also gelatinizes.

HAUERITE, $\mathrm{p} .188 . \mathrm{H}=4 ;(\mathrm{A}=3 \cdot 46$; isometric ; rodlish brown, streak brownish-red. B.B. yields sulphur, after roasting roaction for manganese.
ALABANDITE, p. 188. H. $=3 \cdot 5-4 ; \mathrm{G} .=4$; submetallic, iron-black; streak green; 13.13. on coal sulphur, aftır roasting reaction for manganese.
Vesuvianite, epidote, axinite, ilvaite, gölhite, include varieties that give reaction for mangranese.

## IV. MINERALS OF METALIIC OR SUB. METALLIC LUSTRE NOT INCLUDED IN PRECEDING DIVISIONS.

## 1. YIELDING FCMES IN TTIE OPEN TUBE OR ON COAI」, BUT NO' WHOLLY VAPORIZABLE.

A. STREAK METALLIC.

MOLYBDENITE, ] 96. H. $-1-15$; त. $-4 \cdot 4-4 \cdot 8$; lead-arny, and leaves truce on papr $;$; $B$ B. on coal sulphurous fumes
 B.B. on coal sulphinr us funce, and yellow bismuth oxide ; sol. in hot nitric acid aud a white precip. on diluting with water

## B. STREAF UNMETALLIC. <br> a. FUMES SCLPICTROLS ONLY.

PYRITE, p. 172. 世. $-6-65$; ( $8-4 \cdot 8-52:$ isnmetric and pritohodral ; pale brass-yellow, treak grh black, buh black; B.B. on coal, fuses to a magnetic globule.
MARCASITE, p. 174. II. $=6-6 \%$; G. -4.68485 ; trimetrir ; pale hronze-yedlow ; streak gyh black, bnh black; B. B. like pyrite.
 bronze-yellow, rdh; streak gyh black; Nlightly magnotic; B.l3. fuses to a magnetic mass.
MILLERITE, p. 164. H. $=3-3.5$; G.- $4 \cdot(6-5 \%$ rhombohedral, usually in acicular or capillary forms, also in fibrous crusts : brassyellow, somewhat bronze-like; B.B. fuses to a rlobuke, reacts for nickel.
LINNHITE, p. 104. H. $=55 ; \quad A=4 \cdot 85$; isometric; pale steelgray, copper-red tarnish; streak bluckish-gray ; 13.1. ou coal fuses
to a magnetic globulo, after roasting gives reactions for nickel, cobalt, and iron.
SPHALERITE, p. 154. H. $=-35-4$; G. $=3.9-42$; isometric; lustre, submetallic: streak nearly uncolored; nearly infusible atone and with borax ; ou coal a coating of zinc oxide.

## b. arsenical fumes, with or without stlpithocs.

ARSENOPYRITE, p. 175. H.-5-6; $\mathbf{A} .-6$ - 6 - 4 ; trimetric; white, gyh, streak dark gyh black. la closed tube, red arsenic sulphide and metallic arsenic ; B.B. on conl fuses to marnetic ghobule.
GERSDORFFITE, p. 166. H.-55; G. $-56-6.9$; isometric, pyritohedral; white, gyh, streuk grayish-hlark. ln closed tube arsenic sulphide, on coal not magnetic, and reacts for nickel and often cobalt.
NICCOLITE, p. 16f. $\mathrm{H}=5-55$; G. $=73-7 \%$; hexagonal ; pale copper-red, streak pale buh black; in open tule, coating of arsoncus acid ; B B . on coal no sulph. fumes, fuses to globule which reacts for irom, cobalt and nickel.
SMALTITE, p. 165. $\mathrm{H}=5 \%-6 ; \mathrm{G} .=6 \div 7 \%$; isometric ; tin-white; streak gylh black; on coal, no fumes of sulphur or only in traces.

## 2. NOT YIEIDTNG FUMES OF ANY KIND. STREAK UNMETALLIC.

## a. b.b. Easily fusible, anil giving a magnetic beai). LUSTRE SUBMETALLIC:

 black, streak guld or buh black; gelat. with II (1
ALLANITE, p. 263. II. $=5 \%-6$; ( $1=342$ : monoclinic: buh pitchblack, streak gyh, buh; B.B. fuses casily; most varietiers gelat. with II (').
WOLFRAMITE, p, 183. II $=5-55$; ( $x .=7 \cdot 1-76$; monorlinic ; wy hack or bnh blark; 13.B. fuses easily, and reacts for iron, manganese, and tungsteu.

## B. INFTSIBLE OI. NEARLI SO.

## 

MAGNETITE, p. 1\%. $\quad$ (.$=49-5.2$; isometric ; iron-black; streak black ; strongly magnetic.
MENACCANITE, 1. 178. G. $=45-5$; rhombobedral; iron-black : streak submetallic, black to buh red; rery slightly marnetic.
 in very thin splinters or scales blood-red by transmitted light; streak red; sometimes slightly magnetic.
MARTITE, p. 177. Same as hematite, but isometric.
TANTALITE, p. 184. $G .=7-8$; trimetric; iron-black, streak rih brown to black.

FRANKLINITE, P. 179. H. $=5 \cdot 5-6 \cdot 5 ; \quad \mathrm{A}=4 \cdot 8-5 \cdot 1$; octahedral, massive; iron-black; streak dark rdh brown; slightly attracted by magnet ; with soda reaction for manganese.
COLUNEBITE, p. 183. G. $=5$ 4-65; trimetrie; iron-black, gyh black, streak dark red to black, often with a bluish sted-tarnish.
 pitch-black ; streak dark rdh brown ; B.B. glows ; fuses with difficulty.
b. REACTION FOR IRON ; MYDROUS; LUSTRE SUBMETALLIC.

LIMONITE, p. 1St. ( $\mathrm{A} .-3 \cdot 6-4$; massive, often stalactitic and tuberose with surface sometimes highly lastrous, often subfibrous in structure; black, buh black; streak buh yellow.
COTHITE, 1 1א:. (i. $-4 \cdot 0-44$; trimetric ; also fibrous and massive ; bkh brown ; streak boh yellow.
TURGITE, p, 1si. (t $3 \cdot 6-4 \cdot 68$; fibrous and massive, lookiner lik? limonite ; black, rdh black, streak rel ; in closed tube decrepitates, which is not the case with göthite and limonite.

## c. REACTION FOR CHROMICM OR TITANIUM.

CHROMITE, p. 180 . H. $-5-5 ;$ (.$-4 \% 46$; ismmetric: submetallie; lmh mron-black, streak brown : B.B. with lorax qives a bead which on exhlag is chrome-green.
 reacts for titanium. Black varieties of brooh itc ( $p$. $16: 3$ ), submetallic in lustre, give same reaction.
Envenite', p. 202 : yttrotantalite, p. 202 : aschymite, p. 202 ; forgusomite, p. :20:, and perofisite', j. 103 , are sulmetallie in lustre.
d. heated witif nitre in a matrass yiedde fomes of osmmam.
P. 127. I. $-6-7$; $7 .=19 \ldots 1 \sim$ in smull scales from auriferous or platiniferous sunds; tin-white, gy'l.

## Y. IDSTRE CNMETALLIC.

## 1. MINERALS HAVING AN ACTD, AIKAITNE, ALCM-LIKE, OR STYPTTC TASTE.

A. CARBONATES: Taste alkaline; cffervescing with HCl.

NATRON, p 299. Efloresces on exposu
TRONA, 1. 230. Does not eflluresce.
B. SULPHATES : No effervescence; reaction B.B. on coal with soda for sulphur.

MASCAGNITE, p. 231. Yields ammonia.
MIRABILITE, p. 2N(6. Monoclinic, crystals stout; taste coul, saline, bitter; B B. flame deep yellow.
EPSOMITE, p. 205 . Trimetric, crystals ordinarily slender, spiculelike ; taste bitter and saline ; B.B. flame not yellow.
ALUNOGEN, p. 197. Taste like common alum.
KALINITE, MENDOZITE and other alums, $p$ 198.
MELANTERITE, $p$. 182. Green ; taste styptic ; reacts for iron.
CHALCANTHITE, p. 13i. Blue; reacts for mpper.
MORENOSITE, p. 16\%. Green; reacts for nickel.
BIEBERITE, 1.168 . Roddish ; reacts for cobalt.
GOSLARITE, p. 156. White; reacts for zinc.
JOHANNITE, p. 1i1. Emerald-green, reacts for uranium.
C. NITRATES: With sulphuric acid. reddish arrid fumes; no action with hydrochloric acid ; deflagrate.

NITRE, p. 2NA. Not eflorescent. Strong deflagration.
SODA-NITRE, p. 20?. Fiflorescent
NITROCALCITE, p . l.4. Deflagration slight.
D. (Cllorines : With sulphuric acid acrid fumes of IICl ; no fumes with HCl .

SALMITAK, p. 230. Taste salinc, pungent ; on coal, evaporates; with sola, odor of ammonia.
SYLVITE, p. 2.4. Taste saline; B.B3. flame purplish.
HALITE or COMMON SALT, p 224. Taste saline; B.B. flame yellow.
E. BORATES. No effervescence with acids ; B B. reaction for boron, when moistrned with sulphuric acid.

SASSOLITE, p. 97. Taste feebly acid; B B. very fusible.
BORAX, p. 22\%. Taste sweetish alkaline: B.B. puffs up.

## 2. MLNELALS NOT HAVING AN ACII, ALKALINE, ALUM-LIKE OR STYPTIC TASTE.

## A. CARBONATES : Effervescing with HCl.

A. INFCSImLE ; ASSAY ALKALINE AFTER TGNITION.

CALCITE, p. 215. H. under 35 ; ( $1 .=25-2.20 ; R \wedge R=105^{\circ} 5$, with threo easy cleavages parallel to $R$; colors various; effervesces readily with cold HCl ; anhydrous.

ARAGONITE, p. 218. H. $-35-4$; G. $=2.94$; trimetric, cleavage imperfect ; otherwist like calcite.
DOLOMITE, p, 219. H. $=3 \cdot 5-4 ;$ G $=2 \cdot 8-2.9$; rhombohedral, $R \wedge R$ $=10011{ }^{\prime}$; colors various ; effervesces but slightly with cold HCl , unless finely pulverized; anhydrous.
MAGNESTTE, $p$ 207. H. $=3545 ; G-3-3 \cdot 1$; rhombohedral, $R \wedge R$ $=107$ 29'; white, ywh, gyh; effervesces but slightly with cold IlCl; anhydrous.
HYDROMAGNESITE, p. 207. H. $=1-35 ; \mathrm{G} .=214 \approx 18$; hydrous.
B. INFUSIBLE; DECOME MAGNETIC AND NOT ALKAIINL AFTER IGNITION.

SIDERITE, p. 18i $I \mathrm{I}=35-45 ; \mathrm{G}=37-39$; rhombohedral, $R: R$ $=100^{\circ}$; cleavage as in calcite ; becomes brown on exposure, chansing to limonits.
ANKERITE, p 180. II. $=3 \cdot 5-4 ; ~ \mathrm{Q} .=2 \cdot 9-3 \cdot 1 ; ~ R \wedge R=106^{\prime} \mathrm{r}^{\prime} ;$ becomes brown on exposure.
Some kinds of catcite and dolomite contain iron enough to become magnetic on ignition.
(.) INFISIULE ; B.T. ON COAL WITH KODA, COATNNG OF ZINC OXITE.

SMITHSONITE, p . $150 \mathrm{H} .=5$; $\mathbf{G} .=4-45$; rhombohedral like calcite: $R \backslash l:=10 a^{\prime} 40$; crystals often an acuto rhombohedron; anlyydrous.
HEDROZINCITE, p. 157. H.=2-2.5; $\mathbf{Q}=3 \cdot 6-3 \cdot 8$; white, gyl, ywh, often curtly ; reacts for zine ; hydrous.

## D. infteidme ; b.b. on coal reaction for nichel.

ZARATITE (Emerald nickel), p. 168. H. $=-3$. Emerald qreen, streak iraler.
C. FUGIDLE ; ASSAY ALKALLNE AFTER IGNITION.

WITHERITE, p. 221. H. =3-3•第; G. $=429-4.35$; trimotric ; white, ywh, gyh; BlB. fuses easily, flame $y$ wh groen ; anhydrous,
 green, gray, ywh, white; B.B. fuses only on thin edges, flam, bright red : anhydrous.
BARYTOCALCITE, !. 2~2. Monoclinic. G. $=3.68 \cdot 66$; D. B. nearly lilse witherite.
Other carbonates are the Lead Carbonate, p. 15N, and Copper Car-
bonates, p. 140, included severally under the heads of Leals and Corn, on page 391.

# B. SULPHATES or SULPHIDES: Reaction for Sulphur with Soda. 

A. FUSIBLE ; ASSAY ALKALINE AFTER FCSION.

BARITE, p. 220. H. $=2 \cdot 5-35$; $7 .=43.72$; trimetric ; white, ywh , gyh, bluish, brown; B.B. decrepitates and fuses; flame jellowish green; anhydrous.
CELESTITE, P. 22.2 . $\mathrm{H}-3.35 ; \mathrm{G}=3 \cdot 9-3.98$; trimetric ; white, pale blue, rdh ; B.B. fuses; tlame red; anhydrous.
ANHYDRITE, p . 211. $\mathrm{H}=3-35 ;(\mathrm{G}=29-30$; trimetric, with three rectangular and easy cleavages differing bat slightly; white, hluish, gyh, rdh, red ; B B fuses, flame reddish-yellow.
 feet, pearly cheavage; white, gray, but also brown, black from impurities; B.B. yields much watier, becomes white and crumbles easily.

## D FUSible; REACtION FOR moN.

COPIAPITE, $\mathrm{p} \cdot 1 \mathrm{AD} . \mathrm{H}=15 ; \mathrm{G}=2.14$; yellow ; on coal, becomes magnetic ; liydrous.
ILailynite, p. 2i0, also gives the sulphur reaction with soda.

## c. Infusible, of nearly so.

ALUMINITE, $p$. 199. $\Pi .=1-2 ; A_{i}=160 ;$ adheres to the tongue; white ; B B3. hlue with cobalt solution. Alunite, p. 100, is similar, but $\mathrm{H} .=4$, and $\mathrm{G} .-2.58-275$.
SPHALERITE, p. 154 II. $=35-4$; $\mathrm{a}=3.9-42$; isometric ; light to dark resin-yellow ; B.B. on coal, coating of zinc oxide.

## C. ARSENATES : Arsenical fumes on coal.

SCORODITE, p. 185. $\mathrm{H}=354 ; \mathrm{G}=3 \cdot 133$; trimetric ; Ierik-green do liver-brown ; B.B. fuses easily, flame blue, and with soga gives a magnetic bead ; on conl alliacenus fumes: in H Cl. sol.
PHARMACOSIDERITE, p. 185. H $=-25: \quad$ Q. $=29-3$; cubes and tetrahedrous; dark green, buh, reddish; B.B. same as for scorodite.
 monoclinic with one eminent cleavage; B.B. fuses, fane blue; on coal, alliaceous fames; after ignition assay alkaline: in HCl sol.

## D. SILICATES, PHOSPHATES, OXIDES : SPECIES NOT INCLUDED IN THE THREE PRECEDING SUBDIVISIONS.

I. Streak deep red, yellow, brownish-yellow, green or black.
A. INFUSIBLE, OR FUSIBLE WITH MUCII DIFFIC'ULTY.

HEMATITE, p. 176. Red to black; streak red; B.B. raction for iron ; magnetic after ignition in R.F. ; anhydreus.
LIMONITE, ]. 181. brownish and ochre-yellow ioblack; streak brownish yellow; B.B. gives off water, turns pod, bedomes magnetic in R F .
TURGITE, p. 182. Brown to black: strak red; 13.B. gives off water : decrepitates; becomes magnetic in R F.
FERGUSONITE, p. 202. Brownish black : infusible.
ZINCITE, p. 155. Red; streak orange ; 1313 . on coal, zine oxidf coating, and conting moistened with cobalt solution, green in R.F.

## B. FUSIBLE WITHOUT MCCII DIFFICDLTY.

WOLFRAMITE, p. 183 (irarish to brownish hlack; streals dark reddish brown to black; lustre submetallic; $(\dot{x}=7 \cdot 1-755 . \quad 13.13$. fuses easily, and becomes magnetie; reaction for tungsten.
VIVIANITE, p. 184. Blue to green (to white): streak bluishwhite ; G. $=-25-2 \cdot 7 ; \mathrm{H}=15-2$, hydrous; 13 B fuse's easily to magnetic globule, coloring flame bloish-green.
TORBERNITE, p. 170 Bright gren, square tabular micaceous crystals ; streak paler green ; H. $=2-25$; hydrous ; yields a globule of copper with soda.
SAIMARSKITE, p. 202. If $=55-6$; $\mathrm{G}-56.58$; velvet-black; streak dark reddish brown ; B.B. fuses on the edges.

## II. Streak grayish or not colored.

## 1. INFUSIBLE

A. GILLATINIZE WITII ACID, FORMING A STIFF JELLE.

CHRYSOLITE, p. 2\%\%. Yellow-green to olive-green, looking like glass ; $\mathrm{H}=13.7$; $\mathrm{Q}=3=3-3.5$; B. B . reacts for iron, becomes magnetic; anlydrous.
CHONDRODITE, p. 2R1 II $=6-65 ; \mathrm{G}=3 \cdot 1-3 \cdot 25$; pale yellow to brown, and reddish-brown ; lustre vitreous to resinous; B.B. reaction for iron and fiuorine ; anhydrous.
ALLOPHANE, r . $2 \mathfrak{2} \mathrm{G}$. $\mathrm{H}=3 ; \mathbf{G}=18-1 \cdot 9$; always amorphous, never granular in texture ; bluish, greenish; B.B. iufus., a blue color with cobalt solution; hydrous.
Willemite, Čalamine, Sepiolite, fuse with great difficulty, and are included under fusible gelatinizing species, p. 402.

B ROT FORMING A STIFF JELLY WITH ACID ; HYDROUS.
a. Blue with cobalt solution (owing to presence of aluminum).

WAVELEITE, p . 201. H -3 2.7-4; G. $=23-2 \cdot 4$; white 60 \&reen, brown ; B. B. Bluish-groen flame after moistening with sulph. acid.
LAZULITE, p. 199. II. $=56 ; \mathrm{G} .-3 \cdot 3 \cdot 1$; blue; B.B. green flame, especially after moistening with sulph. acid; hydrous.
TURQUOIS, 1. 200. II. $=6$; $4 .=2 \cdot 2-285$; sky-blut, pale grean; B.B. flame green.

RAOLINITE, p. 310. 1I-1-2; $\mathbf{i}=24-265$; white when pure; feel $r$ reasy ; B. 3 flame not green.
 ish; B B. flame not green ; soluble in strong sulph. arid.
DIASPORE, p. 191. II. ( $6 \cdot 7$; ( $\mathbf{1} .=3 \cdot 3-3$; in thin foliated crystals, plates or scales; white, greenish, brownish ; B.B. flame not grean ; suluble in sulphuric acid after ignition.
3. Pale red or pinls color, with cobalt solution (owing to presence of maguesium).
 ish ; foliaceous or fibrous and flexible; B 13, after ignition, alkaline.

## c. Noi blue or red with cobalt solution.

OPAL, р. 2ne. H. $=55-65$; G. $=1.9-2.3$; P. B. with soda solable with reffervescence.
GENTHITE, p. 309. H. $=3-4$; C. -2.4 ; pale rreen. yellowish; B.B with borax a violet bead, becoming gray in R.F. owing to nirkel; decomp) hy II (T.
CHRYSOCOLLA, 1. 142. H. $=2-4$; $\mathbf{A .}_{2}=22.24$; pale bluish-grenn to sky-blue ; B. B. flame emerald-green, and with soda on coal globule of copper.
The micas, chlorites, chloritoid, and serpentine often fuse on their odges with much difficulty.
C. NOT FOMMING A STIFF JELLY; ANHyDROUS. II. $=-5$ to 9.
a. Blue color with cobalt solution.

CORUNDUIM, 1. 192. H. $=\mathbf{9}$; G. $=4$; rhombohedral ; blue, white, red, gray, brown.
CHRYSOBERYL, p. 196. H. $=8.5$; $\mathrm{G} .=37$; gray, green, to emerald groen.
TOPAZ, 1.286. II. $=8$; $4 .=3 \cdot 5$; in rhombic prisms with perfect basal cleavage, rarely columnar; white, wine-yellow, and other shades.
RUBELLITE, p. 283 . H. $=7 \cdot 5$; G. $-\mathbf{3}$; in prisms of 3 , 6 , or 9 sides ; rose-red ; reaction for boron.
ANDALUSITE, p. 284. H. $=7 \boldsymbol{7}$; $\mathrm{G} .-3 \times 3$; always in prismatic; crystals, often tesselated within, $I 八 I=93$; grayish-white to brown.
FIBROLITE, p. 285. H. $=6-7 ; \mathbf{G}=3 \cdot 2$; columnar or fibrous forms and prismatic crystals with brilliant diag. cleavage.

CYANITE, p. 280. H. $=5-7$ (qreatest on extremitios of crystals) ; G. $=3 \cdot 6$; in long or short prismatic crystallizations, often bladed prisms ; pale blue to white and gray.
ZEUCITE, p. 2\%1. II. $=55-6 ;(\mathbb{5}=25$; white, gyh; often in trapezohedral crystals.
b. Not giving a blue or reddish color with cobalt solution ; H. = 8 to 5.

SFINEL, p. 194. IT. $=8 ;(4=8 \cdot 6-1$; in octahedrons of red, greenish, gray, black colors. Gabrite is similar, but with boras on conl, gives reaction for zinc.
BHRYL, P. 252. $\mathrm{H}=7.5-8 ; \quad \mathrm{G}=\mathbf{2}=\mathbf{2}-\boldsymbol{2} \%$; always in hexagonal prisms ; pale bluish and yellowish green, to emerald-green, also resin yellow and white, no distinet clatare.
ZIRCON, 1 259. H. $=75 ; \mathrm{G}=4-1.5$; dimetric, and often in squaro prisms; luster adamantine: brown, gray.
STAUROLITE, 1 . $291.11 .=7$; G. $=34-3:$; in prisms of 123", aud often in cruciform twins; no distinct cleavare ; brown, black, gray.
QUARTZ, p. 233 . II. $=7 ; \mathrm{X} .=26$; often in hevagomal erystals with pyramidal terminations; of various shates of color. Oraf, p S39, is in part anhydrous.
MONAZITE, P. 203. II. $-5-5$; ( $4 .-49-5 \cdot 3$; in small brown imbedded monoclinic crystals, with perfect basal cloavage; 13.B. Hane bluish-green when moi-tened with sulph. acid.
RUTILE, 1 (10. H.:-6-65; $6 .-4 \cdot 15-29$; dimetrie; reddishbrown to brownish-red, preen, hack; B.13. reaction for titanium. brookite and Octancmites, p. 163 , ure similar, exefpt in cryshaline forms, and $G$. in brookite $4^{10-425}$, in ortahedrite $3 \cdot 8-3 \cdot 05$.
PEROFSKITE, p. 1ti3. H. $=5 \%$; ( $\mathrm{i} .-1-1 \cdot 1$; yollowish, brown, black : cubic and octahedrul forms ; B B reachon for titanic acid.
ENSTATITE, 1.244 . H. $-5 \cdot 5$; $G .=3 \cdot 1-3 \cdot 3$; in prismatic and fibroas forms with $I \wedge I=88$ 16', also foliated; whitish, grayish, brown. Authophyllite is similar, but $I \wedge I=125^{\prime}$, and it fuses on the edges with great difliculty.
Iolite, apatite, schelitr, eurluse, fuse with murh difficulty, and cuclase gives some water in closed tube when highly ignited.

## 2. FUSIBLE WITH LITTLE OR MUCII DIFTICULTY.

## A. Gelatinize and afford a Stiff Jelly.

## a. Hydrous; fuse easily.

DATOLITE, p. 289. II. $=5-5$; $\mathbf{G}=2.8-3$; white, greenish, yellowish ; rystals ghasy, stout, sometimes massive and poredlanous, never fibrous; B. $B$ fuses easily, reaction for horon,
NATROLITE, p. $2 \mathscr{O} 9 . \quad \mathrm{H}=5-\tilde{5} 5$; $\mathrm{G}=2 \cdot 2 \cdot 2-24$; in slender rhombic prisms, and divergent columnar ; white, $y$ wh, rdh, red; B.B. fuse's very easily.
SCOLECITE, p. 209. H. $=5-55 ; G .=2 \cdot 10-24$; cryst. much liko
natrolite, but twinnel, with eonverging strix on $i$ - $i$ as in figure on p. 299 ; B. B. sometimes curls up, fuses very easily.

GIMELINITE, ]. 301. H. $-45 ; G .=2-2.2$; in small and short hexagonal or rhombohedral cryst. ; B.B. fuses easily.
PHILIPPSITE, p. 302. H. $=4-4.5$; $\mathrm{G} .=2.2$; in twinned crystals ; B.B. fuses rather easily.

LAUIMONTITE, p. 293. H. $=35-4$; $\mathrm{Q} .-2.2-24$; white, reddish; crystals become white and crumbling on exposure to the air ; B.B. fuses rather easily.
Pcctolite (p. 293 ), and Anulcite (p. 299), imperfectly gelatinize.

## b. Hydrous; fuse with much difficulty.

CALAMINE, p. 15\%. $\Pi .=4 \% 5 ;$ G. $=315-319$; white, greenish, bluish ; orthorhombic in crystals; B.13 fus. with great difficulty, roaction for zinc and none for iron; hydrous.
SEPPIOLITE, p. 306. White; soft and almost clay-like, also fibrous; B B. fuses with difficulty, with colmalt solution reddish; liydrous.
PYROSCLERITE, p. $31 \%^{\circ}$. II. $=3 ; \mathrm{G} .=274$; micaceous; B.B. fuses on thin edges.

## c. Anhydrous.

a No meaction for sumpit ; No conting on coal.
NEPHELITE, P 269. H -5:-6; G. $-25-2 \cdot 6$; hexagonal prisms and massive ; vitreous, with greasy lustre; white, ywh, gyrh brown, rith; B 13. fuses rather easily.
WOLLASTONITE, p. 2A4. II $=45-5$; $G=2 \cdot 75-29$; white, gyh, rdh, bonh ; B. B. fuses easily.
SODALITE, 1. 270 II. $-5-6 ;$ Q. $=2 \cdot 13-4$; white, Wue reddish ; in dodecahedrons and massive; 13.13. fuses not very easily.
WILLEMITE, 1. 15\%. II. $-5 \%$; (i. $-3 \cdot 9-4 \cdot 3$; white to preenish, reddish, brownish; 13 [3. glows and fuses with difficulty ; reaction for zine and noue for iron; auhydrous.

## $\beta$. Reaction for sulpher b.b. witm sod.

HAUYNITE, p. $270 . \quad \Pi .=5 \pi-6 ;(\pi=2.4-25 ;$ blue, greenish; isometric, in dodecahedrons, octahedrons; B.B. fuses with some difficulty.
DANALITE, p. $256 . \quad \mathrm{II}=55-6 ; \mathrm{G} .=3.427$; isometric ; Hesh-red to gray; B.B. fuses rather casily, and gives reaction for manganese and ziuc.

## B. Not Gelatinizing.

1. Structure fminently micaceous, surface of folla mole or less pearly ; H. of surface of folla NOT OVER 35 ; anhymrous or hydrous.

MUSCOVITE, BIOTITE, PHLOGOPITE, LEPIDOLITE, LEPIDOMELANE : for distinctions sce pp. 206-268. Auhydrous,
or affording rery little water; B B. fuse with difficulty on thin edges, excepting lepidomelane which fuses rather more easily.
MARGARODITE, DAMOURITE, p. 313. Much like commen mica, but more pearly and greasy to the feel, folia net elastic ; giving a litule water in the closed tube ; color usually whitish.
PENNINITE, RIPIDOLITE, PROCHLORITE, p. 318. Tisually bright or deep green, blackiwh-greete, reddish, rarely white; folia tough, inelastic ; B B. diff. fus., reaction for iron and yield much water: partially decomposed by acids.
VERMICULITE, JEFFERISITE, $p$ 317 Brown, ycllowish-brown, grecu; exfoliate remarkably ; yield much water.
MARGARITE, p. 319. $\mathrm{H}=3 \mathrm{~F}-4 \mathrm{~F}$ (highest on edges) ; (i..-209; white, wh, rulh; folia somewhat brittle; B.B. fures on thin edges; yields a little water.
TALC, P. 304. II. $=1-15$; G. $=2: 5-2.8$; parly and very greasy to the thuch, white, pale green, gray; I 13. very difliculily fusible, vieds usmally traces of water; reddish with cobalt molution
PÝROPHYLLITE, p 306 . Sinilar to tale ; hut B.B. "sfoliates remarkably ; blat with coball solution.
FAHLUNITE, p. 314, has often a more or less distinct micaceons structure.
Autnute, p. 170, has a mica-like hasal clearage : hut it occurs in small square tables of a bripht yellow coldr. Jiollagy, p. 246, has a structure nearly micaceons. firpentine is sometimes nearly micacerus, but the folia are not casily separahle and are brittle. Chloritrid has a perfect basal cleavage, but folia very brittle, and clearage less easily obtained than in the jreceding; and moreover the mineral is infusible.

## 2. Sthucture not micaceous. <br> (1. Hydrous.

## $\alpha$. No reaction for phosphorth, or boron.

+Hardness, with the exception of a variety of serpentine, 1 to 3 ; lustre not at all vitreous.
OHLORITES, p. 318. $\mathrm{H}=2-2.5$. Here fall the massive pranular chlorites, olive-green to black in color, of the species porminite, ripidolite, prochlorite; B.B. reaction for iron, fuses with difficulty; yields much water.
VERMICULITE, p. 31\%. H. -1-1\%. Granular massive forms of verniculite.
TALC, p. 304. IT. $=1-15$. Here falls steatite (soapstone) or massive tale, of white to grayish green and dark green color, erranular to rryptocrystalline in texture. B.B. fuses with great difficulty, and yields only traces of water; no reaction for iron, or only slight.
PYROPHYLLITE, p. 306 Grayish white, marsive or slaty; B.B. like the crystallized, p. 403, in its difficult fusibility and little water vielded, but does not exfoliate.
SERPENTINE, p. 307. II. $-2 \cdot 5-4 ;$ G. -2 236-2.55; olive-green ; ywh greeu; blackish green, white: B.B. fuses with difficulty on thin edges; yiclds much water.

PINTTE, p. 31~. H. $=2.5-35$; ( $\mathrm{A}=2 \cdot 6-285$; lustre fertly wasy ; gray, gnh, buh. B.B. fuses ; yields water.
DAMOURITE, p. 313 . Same as crystallized, p. 403, but in mas. sive aggregation of acales.
t+ Hardness 35 to 65 ; lustre often pearly on a cleavage surface, but elsewhere vitreous.

PREHNITE, p. 205. H.- $;-65$; G. $-2.8-3$; pale groen to white: crystals often barrel-shaped, made of grouped tables; 13 B. fases very casily ; decomp. by If (\%.
PECTOLITE, 1.203 . $1 \overline{2}-5 ;(4=2 \cdot(08-28$; white ; divergent fibrous, or acicular ; B.B. fuses very easily; gelatinizes inuperfectly with H('l.
APOPHYLLITE, 1 20t. II. - $45-5 ;(1 .-20-2 \cdot 1 ;$ white, gnh, 5wh, rdh; dimetric, one perfert pearly cleavage transverso fo prism; 13. B fuses very easily ; a lluorine reaction; decomp. by II Cl.
 white, rilh; B l3 fases casily; decomp by II (Cl.
HARMOTOINE, $p .301$ II $=45$; (x. $9 \cdot 44$; white, ywh, rdh; crystala twini, usually cruciform ; 1313 fases not very easily; vitreousiu lustre ; decomp. by IICI.
 tallizations ofter radiated-lamellar; one perfect pearly cleavage; B. P. exteliates, fuses easily ; deromp. by II ('l

HEULANDITE, p. $303 \mathrm{H}-3504 ;(\dot{1}-22$; in oblique erystals, with our perfect pearly cleavage; B.B. same ass for stillite.
EUCLASE, 1. 2SY. II. $-7-5$; A. $=31$ : in glassy transjarent monoclinic crystals; B. 13 fases with great difficulty; gives water in closed tube when stronely igmiticl.
Prehnits, "poqhyllite", rhaluraite, harmotome, henlandite, and cuclasa never oceur in fibrous forms.

## ß. Reaction eitier for thospiomits or boron.

VIVIANITE, P 184. $\mathrm{H}=15-2 ; \quad \mathrm{G}=2 \mathrm{a}=7$; monoclinic with one perfect cleavage; white, blue, green; B.B. fuses very casily, the flame bluish green, a gray magnetic globule; in II Cl sol
ULEXITE, p. 212 H. -1 ; (1-1-65; white, silky, in fine fibres; B.B. fuses very easily, and moistened with solph. acid flame for an instant green, owing to the boron present; little sol. in hot water. Prioeite (p. 2t2) is in texturo and color like chalk; similar to ulexite in green flame 13 B .
Borar and Sisssolite are other soft minerals containing boron, but these have taste.

## b. Anhydrous.

## $\alpha$. B.B. the flame lithium-red.

SPODUMENE, p. $248 \quad \Pi=65-7 ; G .=313-3 \cdot 19$; white, gyh, gnh white, monoclinic (like pyroxene), with $I \wedge I=87^{\prime \prime}$, and perfect cleavage parallel to $I$ and $i-i ;$ B.B. swells and fuses.

PETALITE, p. 248. H. $=6-6.5 ; \mathrm{Q}=2 \cdot 4-25$; white, gray, rdh, gnh; B.B. becomes glassy and fuses only on the edges.
HEBRONITE, AMBLYGONITE, p. 199 H. $=6$; ( $\bar{x},-3-3 \cdot 1$; mountain green, gyh, white, bnh; 13 B. fuses very easily, ruaction for thuorine.
TRIPHYLITE, p. 190. $\mathrm{I}=5 ; \mathrm{a}=3 \cdot \boldsymbol{\sigma}-36$; greenish gray, blaish, often buh black externally; B.B. fuses very casily, globule magnetic: with soda, mangranese reaction.
LEPIDOLITE, p. 268. II $=2 \cdot 0-4 ; Q=2.8-3$; micaceons, also sealygranular; rose-red, pale viohet, white, gyh; B13. fases easily: after fusion gelat. with II (\%. Some biotitr, j. 266 , gives the lithia reactions.

## (3. B.B. boron reaction (green flame).

TOURIVALINE, p. 28: H. $=7$; $\mathrm{G} .-2 \cdot 0-8 \cdot 3$; rhombohedral, prisms with $3,6,9$ sides, no longitudinal or other distmet chowage : hark, blue black, areen, red, rarely white; lustre of dark var. resiuous ; 13. B. fusion easy for dark var. and diff. for light.

AXINITE, 1. $26.4 .11 .=65-7 ;$ ( $8 .=-32 \pi$; trichinic, sharpeedged, glassy crystals; rich brown to pale hrown and grayish; 13.13. fuses readily ; with borax violet bead.
BORACITE, p. 206 . II -7 ; $\boldsymbol{*} .-2.9 \%$; isometric: white, gyth, gnh; lustre vitrens; fuse featily, coloring hame gren.
Danburite, p. 264, is amother boron silicate.

## $\gamma$. B.B. reaction for titanium.

 in thin sharp-edged crystads: brown, ywh, pale green, black; lustre usually subresinous: li.B. fuses with intumescence.

## \%. Reaction for fluorine or phosphorus.

 the flotme of " candle ; soluble in sulph. acid which hrives off hydrogen fuoride, a gas that cormodes class.
 octahedral cleavage, and masswe; white, wine-yellow, green, purple, rawe red, and other bright tints; phesuphoresees; when heated, decregitates; B.B. fuses, coloring the flame red; after ignition, alkaline.
Lepidolite (p. ac8), Amblygonite (1. 199), also crive a fluorine reaction.
APATITE, p. 21․ H. $-45-5$; $\quad$. $-2.9-35$; often in hexagona? prisms ; pale green, buish, yellow, rdh, bnh, pale violet, white; B.B. fases with difficulty, moistened with sulph acid and heated, flame bluish green from presence of phosphorus ; sometimes reaction for fluorine.

## $\varepsilon$. Reaction for iron.

GARNET, p. 256 . H. $=65-5$; $\mathrm{G} .-3 \cdot 15-43$; isometric, usually in dodecahedrous ani trapezohedrons, also massive, never fibrous or columnar ; red, bulu red, black, cinnamon red, pale green, to emerald-
green, white. B.B. dark-colored varieties futn easily, and give iron reaction, bat cmerald-green var. almont infusible ; a white to yellow massive garnet is hardly determinable without chemical analysis.
VESUVIANITE (ldocrase), p. 261. 11. $=6.5 ;(\mathrm{i} .=3 \cdot 85-8-45$; dimetrie and often in prisms of four or cight sides, never fibrous; brown to pale green, ywh, bk; B.B. fuses more casily than gamet; reaction for irun.
EPIDOTE, p. 2in. IT. $-6-7 ; G .-3 \approx 0-35$; in monoclinic eryst. and massive, rarely fibrous; malile amphibole in having but ono cleavage direction ; ywh green, linh green, black, rih, yellow, dark gray: B B. fuses with intumeseonce.
AMMFHIBOLE, dark varieties including hornllende, artinolite, and
 monoclinic, in short or long prism : often long fibrous, lamelar, and massive, prisms unually four or six sides, $I /, 1=19 t_{2}^{!}$, cleavage par. to $I ; 13.13$. fusion easy to modr rately dificult.
ANTHOPHYLLITE, 1 . 2\%), like hornblende; bun gray to bnh green, sometimes lustre metalloidal ; 13.B. fuses with ereat diffculty.
PYROXENE, angite, and all preen to black varioties, 1.245.
 lar, columnar, not often long. fibrous or asbestifome prisms usaally with four or eisht sides, $1 ; 1=86^{\prime} 5$ ', cleavage par. to $1 ; \mathrm{B} .13$. as in hornhlemde.
HYPERSTHENE, p. 24. II. -5-6; (7.-5.89; cryst. nearly as in pyroxene, hut trimetric, usually foliated massive also fibrous; buh green, wh black, pinchbeck-brown; B.B fuses with more or less difficulty. I) Pomif, p 214, is similar and almost infusible.
 like violet-blne glans; B.D. fuses with much difiicuity.
Tourmuithe, much Titanite, and Ilvate (1. 263), 13.B. gire iron re. action.

## ऍ. No reaction for iron.

SCHEELITE, p. 12. II. $=4 \pi-5 ;$ Q. $-5 \cdot 0-6 \cdot 1 ;$ ywh, gnh, rdh, pale yellow; lustre vitreous-adamantine; fuses on the edges with great difficulty.
SCAPOLITES, 1. 208 . II. -5.5 ; $4 .=2.6-24$; dimetric. often in square prisms; white, gray, guh gray ; B.B. fuses dasily with in. tumescence.
 and lamellar massive, cleavage in only one direction.
AMPHIBOLE, white vur. (tremolite), p. '24). Sume as for other amphibole (abore), except in color; B.B. fuses.
PYROXENE, rfile war., p. 215. Same as for other pyroxene (above), except in color: B. 13 fuses.
ORTHOCLASE, 1. 278. H. $=6.65 ; \mathrm{G} .=2.42 .62 ;$ monoclinic, stout cryst., and massive, never columnar, two anequal cleavages, the planes at right augles with one another, and cleavage surfaces never finely striated, as seen under a pocket lens or microseope; white, gray, Hesh-red, bluish, green; 13.B. fuses with some difficulty.

ALBITE, p. 277, OLIGOCLASE, p. 276. $\mathrm{H}_{-}=6 ; \mathrm{G}=2.56-2 \cdot 72$; triclinic, but cryst. as in orthoclase, except that the two cleavage planes make an angle of $932^{\prime \prime}$ to $94{ }^{\circ}$, and one of them has the surface striated; white unually, flesh-red, bluish; B.B. fuse with a little difficulty ; not acted on by acids.
LABRADORITE, 1 . 276. H. $=6$; ( $x=2 \cdot 66-2 \cdot 76$; triclinic, like albite in reyst., and nearly in cleavage angle, $93^{\prime \prime} 20^{\prime}$, and in strix of surface; white, flesh-red, bnh red, dark gray, gyh browa; B.B. fuses casily; decomposed hy HCl with difficulty.
ANORTHITE, p. 2\%i5. II $=6 ;-7 ; Q=2 \cdot 66-2 \cdot 78$; cryst. and strim as in albite, cleavage angle $94^{\prime} 10^{\prime}$; white, gyh, rdli ; B.B. fusion diflicult; decomposed by HC'l with separation of gelat. silica.
MICROCLINE, 1 . 2 is Very near orthoclase in all characters, but triclinic, cleavare angle differing only $16^{\prime}$ from a right angle, and surface of most perfect cleavage striated, but stria exceedingly fine, often difficult to detect with a grood pocket lens, and requiriug the aid of a polariscope ; color white, , gray, thesh-red, often grecu.

For optical distinctions of Feldsishes, see p. $2 \%$
EUCLASE, $p$ 2N8. $\mathrm{H}=75$; ( 1.31 ; in monelinir crystals, with oue perfect diagonal cleavage; pale green to white, buh, trans parent; beeomes electric by friction.

## ON ROOKS.

## I. CONSTITLENTS OF ROCIKS.

Rocres are made up of mincrals. A few kinds consist of a simole momeral atone: as, for example, limestone, which may be mother the species ralcite or dommite; guartzyte (along with mach samdinne), which is guatt ; and felsyte, which is orthoclase. Rat aren these simple kinds ate soldom free from other ingredients, and often contain risihy other minerals. Nearly all humb of rocks are combinations of two or more minerals. They are not delinite compounds, but indefinite mivfurs. and hardy less indefinite than the mud of a mmeflat. 'The limits between kindz of rorks are consumenty ill-todined. (imanite oraduaters insonsibly into guriss and gneiss as insensbly into mica schist and quartzyte, syenyie into sranite, mica schisi into homblende schist. granito alow into a compact porphyry-like rock, and trachyte; and so it is with many other kinds. The fact is a chict source of the difficulty in studying and defining rocks, and esperially the ervsabline kinds. The different rocks are not speries in the sense in which this word is used in seience, but only kinds of rocks.

The mincrals which are the chief eonstituents of rocks are of two classes: (A) the siliceous; (B) the Culdereous.

## A. The siliceous are as follows :

1. (umert:, which probably makes up one-third of the rocky material of the crust of the globe.
2. The Feldspars ( $p .2{ }^{2} \%$ ) ; of which orthoclesp (with microcline) is most abundant; next to it, olifoclase and labradorite : and next albite, andesite, and anorthite.
3. The Micts (p. 265) : musrovite and biotite, of equal prominence, the others much less common.
4. 4 mphibole and P'yroxene species (p. 245, and beyond): especially hornblende or black amphibole, and augite or
black pyroxene ; also the green hornhlende or actinolite; the green foliated hornblende called smuraydite, and the foliated pyroxene sometimes wrongly called hypersthene, and another rariety ealled diallaye ; also oceasionally the species hypersthene and enstutite.
5. The Feldspar-like mincrals, nophetite (p. 269) and lewcite (p. 2**1). which are related in constituents and quautivalent ratios to the feldspars, alumma being the only sesquicside lase, and hume, potash, and soda the protoxide bases afforded in amalyses; the atomic ratios for the protoxides, sesquioxide, and silica being in nephelite. 1:3:4, as in :morthite; and in leucite $1: 3: 8$, as in andesite. Also, less ahundantly, sorlelite (p. 2ro), which has cessentially the ratio of anorthite and nephelite.
6. Minerels of the Stussurite group. These jade-like specten differ from the felldpars- (1) on being always tinegranular in texture; ( 2 ) in having a high density, (.$=$ \%a-3.t; in barsing from the feldejar type chemically. They are near some soda-lim. fehtapars in constituents, but not always in the atomic relations of the constituents, nor in the absence uniformly of magnesial. There are two prominent kinds. One is between morthite and zoisite in compesition (see p . 263 ) ; yet, unlhe there minerals, its analystrafford several jer cent. of soda and some magnesia. The seromd approaches labradorite: Dulesse obtained for a specimen from Mi. (enemere ( $\mathrm{Al} p \mathrm{~s}$ ), Silica $49 \% \%$, ahumina 2960 , irou protoside $0 \cdot 85$, magnesia 0.36 , lime $11 \cdot 15$, sola
 Silesian sperimen afforded Som Rath nearly the same result. A fhired kind from Corsica, acording bo Boulangers amalywis, has nearly the same comporition as zosiste. A fomith is juderite ( p . 2f:3), a stone occurring in the Swiss lahentwell-ings-but not yet found in the sanssurite rochs of switzerland.
The saussurite of Siberia and the Alys has been observed to have sometimes the form of twins of a triclimic feldspar. This, and the texture, density, and compsition, show that sabssurite is, in part at least. isendomorphous, and in some regions, after lalmadorite. By some peculiar conditions in the process of metamorphism-perhaps long-continued heat with an mosual amount of moisture-the feldspar crystallizations that formed in the incipient stages of the process were afterward changed to a species of higher density and
different molecular nature ; in other words, to saussurite. some of the material appears to be still labradorite.
7. The iron-hearing minerals, Epidote (1). 2(iz), (Garnot (1. 256 ), ( $1 / 2 y$ solite ( 1 . 255 ), wheh characterne some varicties of rocks.

IB. The calrareous species are calcite or calcium carbonate (p. 215), in various states of impurity ; and dolomite or cal-crum-magnewium (arbonate ( p . 219), which in its roch-form is undistinguishable in extermal appect from calcite.

Giypsum, or hydrous calcium sulphate, is also a constituent of beds amongrocks, and should have its place in the list, althongh not strictly embraced under the tern calcar'cous.

Of the siliceons minerals, orthoclase (with microcline), and the two micas, muscovite and hotite, are related in eomposition, in that each affords 10 per cent. or more of potash. Leucite is another allicd potash-alumina silicate, even richer in potash tham orthochase, it containing 17 to 21 per cent. The rocks characterized by these minerals are hence rich in potash.

Albite and oligrochase, and also sodalite, afford mnch soda, the first two memally 8 to 12 per cent., and sodalite, 20 to 25 per cent. Nephelite (elapolite) is also a soda mineral related to the feldspars; but, with 15 to 16 per cent. of soda, there are 5 or 6 of potash ; rarcly the alkali afforded is all soda.

The ordinary kinds of hornblende and pyroxene, on the contrary, afford little or no soda or potash. They thus differ widdy from the potash and soda species just mentioned, and naturally characterize for the most part a distinct series of rocks.

Much importance has been allowed in lithology to the distinction of foliated under the species hornblende and pyroxene: when, in fact. neither in mineralory, as all treatises admit, nor in lithology, has it more than a very subordinate value. The character oltained this distinction before it was fully understood that the foliated forms were identical in composition with those in crystals or in massive forms.

Hornblende does not differ from augite in composition; but since the difference in erystallization is connected with a difference in the physical conditions altending their origin,
and since rocks of each kind often have a rast extent orer the earth's surface, the distinction as to whether a rock is hornblendic or augitic is of prominent geological interest.

## II. CLASSES OF ROCKS.

Rocks are of different classes, according to their texture and origin.

1. Frigmentil. A large part of common rocks were formed of sand, or pebbles and sand, and are only consolidated samd-beds or gravel-beds; and other related hinds aro more or lose consolidated mud-beds or clay-beds. The mudbeds of an estuary, or of the shallow seas off a coast, and the stratified sand and eravel aceumulations of sca-shores and valley formations, are preceisely the kind of material which by consolidation have made the fragmental rocks, the most ahmudant rocks of the earth's surtace. Each pobble, grain of sand, and constituent particle of the man, was derived from preexsting rocks, and is either an actual fragment from those roeks, or else a fragment altered by more or less complete decomposition. The rocks are hence callod frugmontal. The pebbles, and often the sands, have a worn surface, and this fadt, together with the structure of the beds, affords evidence that they are fragmental. They are also the sertimentar! rocks of geology ; for the materal was for the most part carried and dropped by waters as sediment is carried and dropped-the waters mainly of the occan which then covered the continents.
2. Chritalline. Other roeksare erystalline. The grains are angular instead of worn, and they crowd upon or penctrate: one another becuase made in one process of erystallization. They are generally angular over a fractured surface because of the clearage planes, like the grains of a surface of broken iron. Granite, trap, white marble are examples of crystalline rocks. When such a rock is distinctly granular there is little difficulty in deeiding upon its being a crystalline rock. If too finc-grained for a positive conclusion with the aid of a pocket-lens, the doubt may usually be removed by tracing it along to places where it is coarser ; and if none such offers, by the preparation of thin slices for microscopic examination.

Crystalline rocks have received their crystalline texture in different ways.
A. By cnoliny from fusion. The rocks thus made are called Igneozs or Emuptive rocks, as, for example, lavas or rolcanic cjections, and all rocks that, like trap, have come up molted throagh fissures in the earth's rocky erust. The depth of the liquid source of such cruptions is unknown. The fact that, at, one epoch, material of the same kind has sometimes been ejected at intervals along a band of country a thousamdmiles in Jength, from northeast to southwest, as 'on the Allantic: coast from Nova Scotia to South Carolima, indicates considerable depth in such cases. They may be older rocks molted over and thrist up to the surface; but if so, the remelted rocks were in many cases those situated deep in the earth's crust, far helow all the strata of its surface.
B. By sulijection to long-continued heat urthout fusion, making metimorphie rocks. Through this means fragmental or sedimentary strata, orer areas of thousands of syuare miles, and many thousands of fect in depth, have been simultanconsly crstallized, tarning the beds that were originally made from sand, gravel, or mud, into granite, gnciss, and wher related rocks, and compact limestones into marhle. The rocks at the time of the change were gencrally undergoing extensive mountain-making uplifts, and it is supposed that the friction attending the movements of the strata may have been an important source of heat for the change or crystallization ; and that the diffusion of this heat was due to the moisture which abounds in unaltered sedimentayy beds. Metamorphic strata retain their former relative order of superposition, having been crystallized in place, that is, withont fusion. Where gramite has been the result, it is probable that the material was sometimes reduced to a pasty state, so that all lines of the original bedding were obliterated ; but even in that case, the granite is gencrally in the place occupied by the material before crystallization. In other cases, including that of some granites, there was not even this degree of approach toward the original condation of the true eruptive rock. During the uptarning, the rooks were much fractured, and the fissures so made became filled with the materials of the adjoining or subjacent rocks, through the aid of the heated moisture present, making veins; and such veins differ widely from those, called dikes, that were made when the fractures deseended to regions of melted rock, so that the fissures became filled with ejected material.

Rocks thus metamorphosed or rendered crystalline aro distinguished as mutemorphic rocks.
C. By chemical deposilion. Waters often hold calcareous material in solution. When carbonic acid (carbon dioxide) is present in any waters, those waters will take up calcimm carbonate, and make calcium bicarbonate ; and when the waters evaporate, the calcium carbonate is deposited. This is the process by which stalactites and stalagmites (p. 216) have been made, and so also calcareous tufa and travertine (p. 43: ). The Gardiner liver region in the Yellowstone lark is noted for its deposits of travertine.

In geyser recgions there are siliceons deposits made by the hot waters, as stated on pare d 40 ; and these also are exemplified in the Yellowstone Park.

Beds of tripolite ( 1 . 241 ) sometimes become consolidated and converted into chert by the waters that penctrate them -these waters containing a trace of alkali or enough to enable them to dissolve some of the tripoli silica, and then a deposition taking place causing consolidation. The flint and chert of the rocks has probably had generally this origin.
3. Calcarfoes Tocks or Limestones. Compact limestones are conimonly of fragmental origin. They have heen nade mainly out of worn or ground-up sholls, corals, and like calcareous material of organic origin-the movements of the ocean having been, and still being, the grinding agency. They were consolidated through the ocean's waters which penctrated the beds taking up a littlo calcareous material, and then depositing at again. It is, in one sense, metamorphism. But when such compact limestomes experience true metamorphism, at, the same time with other strata, they become distinctly crystalline-gramular, and often very coarsely so, making crystalline limestone or marble.

## III. ON SOIIE CHARACTERISTICS OF ROCKS.

1. Cermtabane Textene. Crystalline lexture varies in coarsences from that in which crystalline grains are visible only under high magnifying power, and the rock is as aphanitie ( $p$. (60) as flint, to that in which they are very coarse. Not unfrequently one of the mincrals appears in large crysials, distributed through the mass- the mass being made of
the rest of the material in a comparatively fine-grained condition. The porphyry of the ancients was a rock of dark feldspathic base, sprinkled all through with hoghtocolored feldspar crystals; and. from this fact, any metamorphic or igneous rock containing such disseminated crystals of a feldspar is said to be poryphyritic.

The following figures illustrate three varieties of porplyritie rock. The first represents a specimen of the red antique porphlyry of Egrpt-now often called Rosso anlicothe rock whech gave the name porphyry to grologr, a kind
1.
2.


Rosso Antico.


Oricutal Verd-antique.
3.


Porphyritic gneiss.
much used by the Romans (though not ly the (irceks or Egyptians), and quarried by them in the mountain l)jebelDokhan, twenty-five miles from the lied Soa, in latitude $2 y^{\circ} \otimes 0^{\prime}$. 'Through the red aphanitic hase small whitish crystals of orthoclase are thickly distributed. Figure 关部 from a polished piece of green antigue poryphyry. The feldspar crystals are comparatively larece and the compact base has a dark green culor. Figure 3 represents a large crystal of orthoclase with the gneiss about, it, from porphyritic pueiss. The feldspar crystals in porphyritic gucis.s or granite sometimes measure three inches i,y one and a half, and amain only a fraction of an inch. These orthoclase erystals, as often in other porphyritic rocks, are twin crystals, the plane of cleavage of one half making an angle of $52^{\circ} 23^{\prime}$ with that of the other half. Occasionally large erys-
tals contain small crystals of mica distributed in one or more lavers concentric with the sides.

The degree of eorseness in the texture of a crystallime rock has been determined chiefly hy the rate of cooling, in connection with the mature of the material. Lielatively rapid cooling produces a fine texture or grain, and very slow cooling a coarser.

A molted rock may cool too rapidly to beome stony throughout, or to berome stone at all; and, in the later case, the material made is ghass. (Common melted glass would he stone on cooling if the process were gradual enoungh.

Figures 4 too 6 represent much-magnified views afforded by transparent slices from glassy rocks, in three of their stages bed wern the pure glasey and the true stony state. In 4, from obsidian, or volcanic glass, of (iremband, there are radiating chasters consisting of hair-like mirrolites (or mirroscopic minerals), calied tribhtes (from the (ireck thrix, hair), such as are common in all ohsodiams. Fig. 5 shows the testure of a variety of pearlite, a light gray rock of
4.


Trichites in obsidian.
5.


Trichites and Fluidal texture in Pearlite.


Microlites in a Pitchstone from Weisselberg.
pearly lustre from the Montezuma Range in the Nerada Basin, as figured by Zirkel; in this, trichite clnsters, besides being very numerous, are arranged in lines or planes, and some of the trichites are jowdered with pollucid grains, or alobulites, which are incipient crystals. Zirkel represents another kind on which the radiating trichites are each a string of globulites. Fig. 6 represents a pitchstone from

Weisselberg (from Rosenbuseh), in which the mierolites are distinctly crystalline in form, and some give eridence that they are foldspar crystals, others that they are ancite and magnetite, and indicate that the rock is intermediate between a glass and a doleryte. Thas there is a passage to ordinary stone. Trap or doleryte has been used for making bottle-glass; and attempts have been made to manufacture glass directly from a variety of granite containing little quartz.

Eruptive rocks, that have come up through fissures. often have glassy particles among the stony in the part near the walls of the fissure when not so through the interior of the mass; and many such rocks, covering large areas, have glassy grains among the stony grains, or a glasey mayma, berause the cooling generally was not slow enough for complete lapidification: or they have an undefined base, when examined in thin slices, which the mieroseope does not resolve into crystalline grains. Such pertions of a rock are described as mmmdicidualized. An mindividualized base exists in the hasalt of Truckee Valloy, the character of a sliee from which, hoghly mannified, is given in fig. 7, from Zirkel ; feldejar crystals, of their usual rectangular forms (fart of them sanidin), one of the largish crystals of chrysolite, and smaller irregularly-shaped augites, are imbedded in a base which consists of a glass-like substance: and in this material there are cxtremely small globulite grams which are globmes of devitrified glass or incipient crystals. The glassy mindividualized base ocenpies the spaces among the crystalline portions.

These differeners in erystalline texture are of small importance compared with differences in mineral and chemieal composition. They are results of aceidente, and, at the best, lead only to a distinction of varidies among kinds of rocks. The presence of a little glass, or of disseminated large crystals in a porphyritie way, does not make the rock essentially different in kind. If, however, the glassy nature is manifest in the external appearance of the mass, it is convenient to call the rock by a seprate name.

Porphyritic rocks are sometimes named as if porphyry was a distinct kind of rock, or as if the porjhyritie section of a kind of rock merited special prominence. But, as recognized beyond, "felsyte-porphyry" is parph yritic felsyte; "dioryte-porphyry" is porphyritic dioryte; "diabase-por-
phyry" is porphyritic diabuse, or, since diabase cannot be distinguished mineralogically from doleryte, it is porphyritic doleryte; and, in these and other like cases, the boing porphyritic is a characteristic of minor value.

Sometines igneous rocks exhibit under the microscope a fluidel texture; that is, the material, when examined in sections, shows wayy lines or bands, which are evidence of a former fluid state, and of movement or flowing when in that state. One variety of this texture is represented in figure 8 (from Zirkel), giving a magnified view of an eruptive
7.


Basalt with the hase unindividualized.
8.

" Rhyolyte;" Fluidal testure.
rock from the head of Lonis Valley, Nevada; and another in figure 5, p. 416 . Such rocks have been comprised under the general name of Rhyolyte (from the (reeck for flowinge) ; but this flaidal textmre is presented by rocks of different mineral constitution, and is hence not a proper basis for a kind of rock.
$\therefore$ Anhydrous and Mydrous Crystalline Rocks. Some eruptive rocks, like doleryte or trap, oceur both anhydrous and hydrons. The latter, mulike the former, have the constituent minerals clouded in aspect, however thinly sliced, and often changed in part to a green chlorite-a hydrous mineral-and abos sometimes to other hydrous species. Such rocks, moreover, have less lustre, and very frequently they are amy!ddaloidal-that is, contain little cavities that are often ahmond-shaped (the Latin amygdalum meaning
almond), which were made by steam, or vapor of some kind, and are now occupied by minerals. This hydrous or chloritic condition is due to alteration, and hence such rocks are properly only varieties of the anhydrous instead of being distinct kinds.

The change was probably occasioned by subterrancan waters, such as exist as streams among the earth's strata, that were eucountered by the hquid rock when on its way up a fissure toward the surface. Hydrostatic pressure prevented the waters from being driven back by the heat, and consequently the vapors ware fored to penetrate the igneous mass. In the region of New Haven, Domm.-lying at the south evtremity of the Comnecticut Valley-the Triassic trap-dikes of the western border of the region, and those outside of the 'Trias, cast or west, in the metamorphic rocks, are ankyitrous, while those in the middle of the valley and cast of this are mostly hytrous, showing a difference in exposure to the watere according to the geographical position of the dikes in the talley. Of two parallel ranges of dikes, not half a mile apart, and following concentric curves in their courses (situated twenty miles and more north of New Haven), ous (as Pereival recognized) is amygdaloidal and hydrons, and the other nearly anhydrous; and the positions of the two kinds, there and elsewhere in the Connectacut Yilley, indicate a general relation between the direction of the prosent valleys and that ot the subterranean water-channels of Mesezair time.

In very nany places coal-like "inspissated bitumen" occurs in the amygdaloidal eavities, wheh was apparently derived from mineral on that the action of the heat on the Triassit carbonaceons shales (in some phaces abomonding in fossil fishes) had cansed to rise in rapors and penetrate the melted rock. The carbonic acid of the calcite that so often eonstitutes the amvedules probahly came from the action of the heat on limestone encountered at the same time. The derevidiand action of the carbohydrogen rapors is supposed by J. Lawrence Smith to account for the metallie iron found in some trap or doleryte. The minerals which constitute the amygdules (see p. $29 \%$ ) are largely such as may hare been made liy the aid of heat and moist ure out of the minerals of the rook itself at the points where they occur.

The water that caused the change could not have come from above after the rock was cooled; for the slight surface decomposition the
anhydrous trap now undergoes shows that such waters do not make their way down : and moreover the results could not have been produced without heat. The trap has not been subjected to a metamorphic process ; for the Triassic beds are unaltered sandstone. The watcr was not from the deep-sented source of the erupted trap, for, if so, the dikes would have been all of one kind, instead of being part hydrous and part anhydrous, and the former locally distributed just as subterranean streams of water are likely to be.

In the case of hydrous metomorphic rocks, whether containing chlorite, tale, or a hydrous mica, the hydrous minerals were, with rare exceptions, made at the time of the crystallization, and are not a consequence of subsequent alteration.

3 Duramblty in Rocks.-Durability in a rork is due largely (1) to compactness and fineness of texture; and ( 2 ) to the absence of any ingredient or mineral that is liable to oxidation. As far within a rock as water and air can gain access, degratation will always be going on. whatever the rock. The alternate melting and freezing of the cold season will be one means of destruction : and direct chemical action of the moist air, and especially of the carbonic acid it contains (p. 10s), will be another. This carbonic acid may take the alkalies out of the feldepar of a granite; and with the commencement of the ation the rock will begin at surface to fall to pieces, or at least to show weakness.

Hence the practice of testing the darability of a stone for architectural purposes, by putting it into water, and then weighing it, after some days of exposure, to see whether it has gained in weight, is a grood one.

Fineness of grain gives further protection against destruction. Altermate heating and cooling in the daily passage of the sun is a destroying agency of great effect, especially on coarse-grained kinds. Rocks have often retained the glacier markings upon them perfectly fresh until now, when they have had a covering of two or three feet of earth; and they have lost such markings after a fow years of exposure. This happens often where there is no true decomposition or oxidation of the surface portion of the rock, and must be due largely to the expansion and eontraction caused hy changing temperature. The finer the grain of the rock the less the chance for this action. There is no more durable rock than a roofing-slate of good quality. Granites, when well polished, will usually resist long all weathering agencies.

The presence of an oxidizable ingredient is a common source of destruction. Pyrite occurs in grains or crystals in almost all kinds of rocks; and it generally oxidizes easily whenever water and air get access to it. Only the firmest erystals resist change, and these not always. A rock containing even a little pyrite can seldom be trusted for architectural purposes. If a limestone contain a few per cent., or cren one, of iron or manganese rephacing part of the calcium, it has a source of destruction within it. The iron and manganese are sure, after a while, to oxidize ; the iron will give susty stans, and the manganese turn it black, and both will work destruction. A chemical trial is needed to asecreain the fact as to the purity or not of the rock. The presence of iron camonate (siderite or pathie iron) is the oreasion, wherever it exists, of rapid deromposition as far down as moisture and air can reach. Thas has been one source of the changes prodncing the great beds of limonte
 rat, and other phaes), in which the rocks are sometimes decomposed to a depht exeeding one handred feet.

It is a fart to be remembered that a rock which has stood the weather for enturies in its natue exposure is a safo material for man's structures ; and one that is crumbling is worth little or nothmg.

Durability depends much on the climate. In Pera, even sun-hurnt bricks wall last for centuries.

The resistance to crushing in rocks is ascertained by subjecting cubs of a wiven size to pressure. In reent experiments hy P. Michelot,* Minister of lablic Works in Erance (whose trials numbered over 10,000$)$. the most compact limestomes, weighing $2, \% 00$ kilograms per eubic meter, were crushed by a weight of 900 kilograms per square reutimetre. Compact oülitic limestone of Bourgogne and some other French localities, weighing e, 600 to 2.600 kilograms, bore roo to 900 kilograms hefore erushing. Statuary and decorative marhles bore 500 to 800 hilograms.

Of granitic rocks from lrittany, the Cotentin, the Vosces, and the Central Platean of France, weighing 2,600 to 2,800 kilograms, the best, which admitted of polishing, bore 1,000 to 1,500 kilograms; while the coarser granites of Brest and

[^8]Cherbourg and the syenyte of the Vosges bore 800 to 1,000 kilograms; and other coarse granites, in which the large crystals of feldspar wero in part decomposed, bore only 400 to 600 kilograms. The green porphyry of Ternuay (Hante Saône), bore 1,360 kilograms; the basalt of Kistelle (I'uy de 1)ome), 1,880 kilograms.

In trials by (ien. Gilmore, trap of New Jersey reguired to crush it $20, \% 0$ to 24,040 lhe a square inch (about $6 \%$ m. sq.) ; granite of Westerly, R. 1., 1r, mon : id. of Wichmond, Va., 21.250 ; srenyte of Quincy, 17.730 ; marble of Tuckahoe, N. Y., 19.950 ; id. of Iorset, Vt., 7, fil2 ; limestone of Joliet, Ill., 11.250 ; sandstone of Belleville, N. J., 10,250 ; id. of Portland, Ct., 6,950 ; id. of Berea, ()., 8,300 : id. of Amherst, O., 6,650 ; id. of Medina, N. Y., 17,250 ; id. of Dorchester, N. B., 9,150.

When absorbent rocks are thoroughly wet the weight required to crush them is greatly reduced. To crush wet chalk, according to trials by Delesse, required only one-third what it did when stove-dried; and for the limestone, "calcaire grossier," of Vitry and other localities, mostly one-third to one-half. Tournaire and Michelot found, for the chalk of the Paris basin, the pressure required when wet two-ninths of that required when the rock had been dried at a temperature considerably above $212^{\circ} \mathrm{F}$.

Twe of the Mieroscope in the Study of Rocks. The study of thin, transparent slices of rocks by the mieroseope is of interest whether the erystalline rock be coarse or fine in texture; but it is partieularly important when of the latter kind. There is no rock so opaque that it cannot be made transparent, or at least translucent, in thin sliees. Such slices are examined by means of a polariseope-microseope. The increased use of the microscope in the investigation of rocks has led to the introduction, by way of distinction in methods of study. of the word macrosern)ic. An investigation may be carried on macroscopicully, that is, without the use of a microscope, excepting a pocket leus; or microscopically, that is, by the study of thin slices through the aid of the microscope and polariscope.

The more important points ascertained by microscopie methods, as regards the mineral constitution of a rock, are the rollowing:

1. The presence or not of quartz; of a feldspar ; of a chlorite.
2. The distinction of a triclinic feldspar from orthoclase, the former showing in sections, cut in any direction excepting one, commonly several parallel spectrum bands, due to multiple twinning in the crystal, while orthoclase shows no bands of the kind, or at the most bui two.
3. The presence or not of hornblende ; this mineral having often cleavage lines meeting at angles of 124", and being dichroic.
4. The presence or not of pyroxene; this mineral often showing cleavage lines meeting at angles of st" (nearly a right angle), and being not dichroic, and usually distinguished in this way from hornblende.
5. The presence or not of mica, its clearage lines and dichroism affording distinctive characters.
6. The presence or not of chrysolite ; of magnetite, its form being often octahedral, and single or grouped; of

points or portions having the nature of glass, and therefore not polarizing light; of fluidal lines; of hopuid cartonie acid, and of varions other intlusions. Fig. ! shows a common form of the gromping of microseopic magnetite crystals in an ermpive rock. Jig. 10 represents a cavity m quartz nearly filled with a liquid, b-the small bubble, $c$, showing the part not occupied by it. When the liguid is cartomie acid the air-bubble disappears on raising the temperature to $86^{\circ}-95^{\circ} \mathrm{F}$. Carbonic acid requires a pressure, at $32^{\circ} \mathrm{F}$. of $38 \frac{1}{2}$ atmospheres to retain it in the liquid state ; and hence occurs liquid only in quartz, topaz, and a few other minerals. Fig. 11 (from Zirkel) shows another eavity, containing, besides a liquid, a little cube and microscopic hornbbendelike acicular crystals; and the cube is supposed to be common salt in a solution of salt. Hexagonal prisms of apatite (calcium phosphate) are detected by the microscope in
almost all kinds of igneous and metamorphic rocks, including trap or doleryte.

For a particular account of the distinguishing characteristics of minerals studied by microscopie methods, reforence must be made to treatises on the subject.

## IV. KINDS OF Rocks.

1. Rocks are gencrally mixtures of two, three, or four prominent mineral constituents, with also others, it may be, of less importance. Each mineral adds a distinctive feature, and might be a reason for a new name. But it is usual with lithologists to base the distinction into kinds of rocks on the two chicf minerals, and make the others aceessory species and the hasis only of varieties. This method is prompted by convenience, and also by the fact that the more important characteristies are commonly contained in two of the constituent mincrals. It has many exceptions, however, and farticularly where a third mineral has special peculiarities and abondance.
2. Difference in kind of rock is naturally based on difference in chemical or mineral constitution, and itleulity, accordingly, on essentiol identity in this respert. (Vonsequently when there is no essential difference in chemical or mineral constitution, there is no sufficient reason for a distinction in kind or a difference in name, unless the wide distribution of a particular variety, and the permanence in its characters, make the distinction in name a grological necussity.

In aceordance with this shatement, the distinctions among crystalline rochs of coarse or fine in texture; of being porpliyritic or not; of containing glasey grains among the stony or not ; of being foliated or not in crestallization, are of little value compared with the real mineral constitution, and are a fit hasis only, at the best. for varieties. But the two rocks of like composition, trachyte and felsyte, retain their characteristics so widely, that geology needs both names, and only demands that their essential identity should be held in mind.

The same kind of rock is in many cases both of metamorphic and cruptive origin ; still the difference of origin is not a sufficient basis for a distinction of kind unless there is some marked difference between them, and an extended
distribution of each, that makes the case like that of trachyte and felsyte. The author has proposed to use the prefix meta for metamorphic kinds when a rock oceurs both metamorphic and eruptive ; but this is not intended to indicate a distinction in kind, but only to abbreviate the qualifying word metamorphic.

According to the principles above stated, a rock having oligoclase or albite as its feldspar constituent cannot rightly have the same name with one having either of the basic foldspars, labradorite or anorthite, as an essential part, although these feldspars are all embraced under the deceptive titlo of plagiorlase (p. 2:5). Betweon anorthite and oligoclase there is a difference of 20 per cent. in the silica, and the former is simply a lime feldspar ; and the contrast is large also between labradorite and oligoclase. Again, for a like reason, as already explained (p. 411), a mica-bearing rock containing little or no homblende cannot properly be classed with hormblendic rocks.
3. It has heensupposed that pre-Tertiary crystalline rocks differerl so decisively from the Tertiary and more recent, that those of the two series should not bear the same name. That geology knows nothing of any epoch of sudden transition in the mineral nature of eruptive rocks at the commencemont of the 'Tertiary era; on the contrary, it shows that the kinds made before and after this epoch are alike in mineral constitution, and differ not always even in texture, hut only in the greater prevalence after the Tertiary of voleanie or subaerial ejected masses, and therefore of rocks of the texture this involves. The distinction of doloryte from diabase, with others similar, is of this chromological kind. Rocks, like other oljeets in science, should evidently be named from what they are, and not from the age in which they may have been mate.
4. Since quartz is the most abundant of all the minerals of the globe, jt , is the least characteristic of the ingredients of compound rocks. Recent lithologists have made it, in sereral cases. distinguish only a section under a kind of rock. Thus, there are dioryte and quartz-dioryte, fresyle and quartz-felsyte, trachyte and quartz-trarhyte. On the same principle there are syenyte and quartz-syenyte, as adopted beyond.
5. The division of crystalline rocks into aciuic and basu: rocks is explained on $p .274$. The acidic afford on analysis

55 per cent. or more of silica, and the basic usmally less than 52.
6. The feldspars are divided, aceording to their bases, into (1) potesh-foldspars, including orthodase and microcline; and ( 2 ) those which may be designated sode-limefoldxpare, namely the species albite, oligroclase, andesite, labradorite, and anorthite, which yield either soda, or lime, or both, on analysis. The term plagiodtese has heen used for the latter ; but it is no longer applicable since microcline is plagiochase. Under the heading potask-feddymers, as used heyond, leacite also is included; and under that of sode-lime-ledepurs, nephelite and sodalite, and also the minerals of the samssurite eroup.

The kinds of rocks are described under the heads of-

1. Fragmental Rocks, exclusive of Limestones.
2. Limestones, or Calgareous Rocks.
3. Crystalline Roces, exclusive of Cimestones.

No strongly defined limit exists between the fragmental and crystalline rocks. But still they are for the most part widely diverse in character and aspect.

In the names of rocks, the termination itr is here changed to yte, as done in the author's " System of Mineralogy" (1868), in order to distinguish them from the names of mincrals. Granite is excepted.

## I. Fragmental Rocks, exclusive of Limestones.

1. Conglomerate. $-\Lambda$ rock made up of pebbles or of coarse angular fragments of rocks of any kind. (a) If the pebbles are rounded, the conglomerate is a pudding-stone; (b) if angular, a breccit.
Conglomerates are named according to their constituents, silicious or quartzose, granitic, calcarenus, porphyritic, pumaceous, etc.
2. Grit.-A hard, gritty rock, consisting of coarse sand, or sand and small probles, called also miltstone grit, hecanse used sometimes for millstones.
3. Sandstone.-A rock made from sand: a cousolidater sand-bed.
Varieties.-a. Siliceous or Quartzose; consisting chiefly of quartz. b Granitic; made of granitic material or comminuted granite. c. Micaceons; containing marh mica. d. Argilluceous; containing much clay with the sand. e. Gritty; hard and containing small quartz peb-
bles. f. Ferruginous; containing iron oxide and having its red color. f. Concretionury; made up of concretions h. Laminated ; made up of thin layers or lamine, or breaking into thin slabs, a characteristic most prominent in argillaceous sandstones. i. Friable; crumbling in the fingers. j. Fossiliferous; containing fossils.

The paving stone extensively used in New York and the nejghboring States is a laminated sandstone, of the uper part of the Hamilton mroup in geology, quarried just south of Kingston, and at many other places on the west side of the Ifudson liver. The rock is remarkable for its very even lamination. In Western New York and in Ohio, the Dovonian sandstones, above the Hamiltou group, together with the Waverly group, afford a similar flag-stone. The " brown-stone" used much in New York and elsewhere for buildings, is a dark-red sandstone from the 'Triassic formation, and is quarried at l'ortland. Conn., on the Connecticut River, opposite Middletown. A lighter-colored " brown-stone" or " fref-stonti." of the same age, also much used for huildings, comes from Newark, Belleville, Little Falls, and other peints in Central New Jersey. The handsome sandstone of light olive-green tint, much employed in architectare, is from the Lower ('arboniferons group in New Brunswick. Thr suft, white sandstone, in murh esteem among architects because so easily cut and carved, comes from Ohio quarries, in beds of the (arboniferous; it is mostly from a bed about sixty feet thick, celled the "Ber"a rrit," and is obtained at Berea and Independence in Cuyahoga County, and Amherst in Lorain County, and else where.

Pyrite is oftern present in sandstones used for huilding, and has defaced, and is destroying, many a beautiful structure by its oxidation, nad the conseguent decay of the rock.

Sandstones absorb moisture most eacily in the direction of the bedling or grain, if there is any distinct hedding ; and hence the blocks, when used for a building or wall, should be placed with the bedding horizontal. It is, further, the position in which the stone will stand the greatest pressure.

Grindstom's are made from an even-graiued, rather friable sandstone, and tre of different degrees of fineness, according to the work to be done by them.

Hard siliceous sandstones and conglomerates, occurring in remions of metamorphic rocks, are called "granular quartz,":
4. Sand-rock.-A rock made of sand, especially when not of siliceons material. A calcareous sand-rock is made of calcareons sand ; it may be pulverized corals or shells, such as forms and constitutes the beaches on shores off which living corals and shells are abundant.

The beach sands bocome cemented below high-water mark into a calcareous sand-rock, which consists of layers having the pitch of the surface of the beach. They are often coarse, calcareous conglomerates.
5. Shale.-A soft, fragile, argillaceons rock, having an meven slaty structure. Shales are of gray, brown, black, dull-greenish, purplish, reddish and other shades.

Varieties.-a. Bituminous shate, or Carbonaceous shale (Brandschiefer of the (lermans), impregnated with coaly material and yielding mineral oil or related bituminous matters wheu heated. b. Alum shale; impregnated with alum or pyrites, usually a crumbling rock. The alum proceeds from the alteration of pyrite or the allied pyrrhotite (p. 174).
6. Argillyte, or Phyllyte.-An argillaceons slaty rock, like shale, but differing in breaking usually into thin and eren slates or slats. Roofing and writing states are examples. It is sometimes thick-laminated. Unlike shale, it occurs in regions of metamorphic rocks. and often graduates into hydromica, chloritic, and mica schists, and also, on the other hand, into shale. Often called clay-slute.

Varieties.- a Bluish-black. b Tile-rech. c. Purplish. a Grayish. e Gereminh; f. Ferruginous. g. Pyrtiforous. h. Thirl-leminuted; affording thick slabs, instead of slates. i. Thich-bedded; a massive rock, affording thick blocks or masses. i. Stomroletic. k. Ottrelitic.

Extensive quarries of slate exist in Vermont at Waterford. Thetford, and duilford, in the eastern slate range of the State, in Northfield in the central range, and in Castleton and rlsewhere in the western range, the last of Lower Silurian age if not the others. There are excellent quarries also in Maine and Pennsylvania The rock furnishes also thick slabs for various economical purposes. 4 trial as to water aboorption, and a close examination as to the presence of pyrite, is reefuired before deciding that a slate rock is fit for use, howcyer even its fissile structure. Kinds with a glossy surface are most likely to be impervious to moisture.
7. Tufa.-- A samd-rock or conclomerate marle from comminuted voleanie or other igneous rocks, more or less altered. Tsalally of a yellowish-brown, gray, or brown color, sometimes red.

Yanieties.-a. Dolerytic or basaltir; tufa made from those igneons rorks that contain irou-bearing minerals, such as doleryte (trap), hasalt, and the heavier lavas; it is usually yellowish-brown or brown in color, sometimes red ; and often consists in part of palaronite (p. 312). b) Trachytir; made of the feldspathic igneous rock, trachyte, of an ashpray color, or of other light shades. a $I^{\prime}$ mimioroms; made of frag monts of pumice. D'sazulana is a light-colored tufa, found in laby. near Rorne, and elsewhere, and used for making hydraulic comfnt, Wacke is an carthy brownish rock, resembling an carthy trap or doleryte, usually made up of trappean or dolerytic material, compacted into a rock that is rather soft.
8. Sand. Gravel.-Sand is comminuted rock-material ; lut common sand is usually comminuted quartz, or quartz and feldspar, while gravel is the same mixed with pebbles and stones. Sand often contains grains of magnetite, or
of garnet, or of other hard minerals existing in the rocks of the region. Occasionally magnetite or garnet is the chicf constituent.

Volcanic sand, or Peperino, is sand of volcanic origin. either the "cinders" or "uskes" (comminuted lavia), formed by the process of ejection, or lava rocks otherwiee comminuted.
9. Green Sand.-An olice-green sand-rock, friable, or not comparted, consisting largely of glauconite. See, for dcreription and analysis, ]. $30 \%$.
10. Clay.-Soft, impalpable, more or less plastic material, chicfly aluminous in composition, white, gray, yellow, red to brown in color, and sometimes hlack. It has been made chicfly from the feldspars, by decomposition. See Kaolinite.

Vamieties. - a. Faolin, purest unctuons clay. b. Potter's clay, plastic, free from iron; mostly unctuous; usually containing some free silica. Pipc-clay iss similar. c. Firc-brick clay, the same; but it may contain some saud without injury. d. Ferruginous, ordinary brick clay, containing iron in the state of oxide or carbonate, and consequently hurning red, as in making red brick. e. Containing iron in the state of silicate, and then failing to turn red on being burnt, as the clay of which the Milwaukee brick are made. f. Alkallne and Vitrificble, containing 25 to 5 per cent of potash, or potash and soda, owing to the presence of undecomposed feldspar, and then not refractory enough for pottery or fire-brick. g. Marly, containing some carbonate of calcium. h. Wcak clay, containing tro much sand for brickmaking. i. Alum-baring, containing aluminous sulphates, owing to the decomposition of iron sulphides present, and hence used for making alum.

The rad pipestone of the North American Indians is an indurated clayey rock from the Coteau de Prairies; it has been named Catlinite; and the $f_{r a y}$ is in part compact argillyte.
11. Alluvium. Silt. Till.-Allurium is the earthy deposit made by rumning streams or lakes, especially during times of flood. It constitutes the flats either side, and is usually in thin layers, varying in fineness or coarsencss, being the result of successive depositions.

Silt is the same material deposited in bays and harbors, where it forms the muddy bottoms and shores.

Lass is a fine carthy deposit, following the courses of valleys or streams, like allurium, but without division into thin layers. Oceurs in elevated plains, along the broad parts of large valleys, as the Mississippi, Rhine, Danube.

Till is the unstratified sand, gravel, and stones, derived from glacicrs.

Detrilus (from the Latin for worn) is a general term applied to earth, sand, alluvium, silt, gravel, because the material is derived, to a great extent, from the wear of rocks throngh decomposing agencies, mutual attrition in running water, and other methods.

Soil is earthy material mixed with the results of vegetable and animal decomposition, whence it gets its dark color aud also a chicf part of its fertility.
12. Tripolyte (Infusorial Earth).-Mesembles clay or chalk, but is a little harsh between the fingers, and seratches glass when rubbed on it. Consists chiefly of siliceous shelis of Diatoms with often the spicules of sponges. Forms thick deposits, and is often found in old swamps beneath the peat.

This soft diatomaceous material is sold in the shops under the name of silex, clectro-siluron, and polishing ponder, and is obtained for commerce in Maine, Massachusetts, Nevada, and California. A bed exceeding fifty feet in thickness occurs near Monterey in ('alifornia; and other large heds in Nevada near Virginia (ity, and elscwhere It is used as a polishing powder; in the manufacture of "soluble glass;" and also mised with nitro-glycerine to make dynamite Occurs sometimes slaty, as at Bilin, Prussia; and also hard or indurated, from consolidation through infiltrating waters, and thus graduates, at times, into ch. rt. Consists of silica in the opal or soluble state.

## II. Limestones or Calcareous Rocks.

## 1. Not CRystalline.

1. Massive Limestone.-Compact uncrystalline limestone usually of dull gray, bluish-gray, brownish, and hack colors, somethmes yellowish-white, cream-eolored, nearly white. and red of different shades; in texture, varying from earthy to compart semi-crystalline. It consists essentially of caicte or catcum carbonate ( p .215 ), but often contains clay or samd, or other impurties.

Varieties.-The varieties depending on color are very numerous, and many of them, when pure and compact, are polished and used for marble. The gray and black colors are due commonly to carbonaceous material, for they burn white ; but the yellow, red, and some other kinds to the presence of iron-oxide. There are also: a. Fussiliffroms or shell limestome. b. Coral or Mredreporic limestome. c. Enrlinital or Criunidal limestone, containing crinoidal remains in the form mostly of small disks. d. Nummulitic: containing the diskshaped fossils called Nummulites e. Ö̈litic limestont; a limestone having an oülitic texture. f. Bird's e eye limestone; having small whitish crystalline points scattered through it, a rock of Western

New York, of the Trenton period in geology. g. Conglomerate limestones.

The black marble of the United States comes mostly from Shoreham, Vermont, and other places in that State, near lake ('hamplain, and from near Plattsburg and Glenn's Falls, N. Y.; also from lsle La Motte. A pudding-stone marble, of various dull shades of color, occurs on the banks of the Potomac, in Maryland, 50 or 60 miles above Washington ; it is used for columns in the interior of the Capitol at Washington.

The Portor is a Genoese marble very highly esteemed; it is decp black, with veinings of yellow; the most beautiful comes from PortoVencse. The Nero-dutico marble of the Italians is an ancient derp black marble ; the parayonc is a modern one, of a fine black color, from Bergamo; and panno di morte is another black marble with a few white fossil shells.

A beantiful marble from Sienna, brocntello di Sirna, has a yellow color, with large irregular spots and veins of bluish-red or purplish. The nutudeluta, of the ltalians is a light red marble, with yclluwishwhite spots. The Madreporic marble is the l'uctra st llatria of the ltalians.

Fircomple, or lemuchelle, is a dark brown shell marble, having brilliant fire-like or chatoraut peflections from within.

Tuia murble is a yellowish marble, with brownish shadings or lines arranged so as to repersent castles, tuwers, or cities in ruins. These markings proceed from infiltrated iron. It is an indurated calcareou* marl, and does not oceur in large slabs.

Hy/traulic limestone is a compact kind containing some clay, and affording a quicklime the cement from which will set under water. An analycis of a kind from Rondout. N. Y., afforded Carbonic acid $34 \cdot 20$, lime 25.50 , magnesia $1: 35$. silica $15 \cdot 37$, alumina 913 , irom sesquioxide 2.5. In making ordinary mortar. quarta sand is mised with pure guicklime and water, and the chemical combination is mainly that betwen the water and lime, together with subsequently an alsorption of carlonic acid. With "hydraulic cement," silica and alumina (that of the clay) are disseminated through the lime, and hence these ingredients enter into chemical union with the lime and water, and make a much firmer cement, and one which "sets" under water.

Oil-bearing limestones ocrasionally occur. A kind used for build. ing in Chicago, of the Niagrara period, beromes spotted or straked with blackish mineral oil, after a few years' 'xposure to the weather.

Some of the pramids of Egypt, including the largest. the 1yramid of Cheops, is made of nummulitic limestone; and this is the building material of Aleppo, the range of monatains between Aleppo and Antioch being composed largely of this cream-colored rock.

A soft 'lertiary limestone occurring in the vicinity of Paris has afforded a vast amount of rock, of an agrecable pale yellowish color, for fine buildings in Paris; and a similar rock has long been used in Marseilles, Moutpellier, Bordeaux, Brussels, and other places in Western Europe.

Most limestones have been made out of comminuted shells, corals, and other like material ; and when of dark colors or black, it is asually owing to some carbonaceous matters present derived from the de
composition of the plants or animals of the waters in which they were formed.

When burnt, limestone $\left(\mathrm{CaO}_{3} \mathrm{C}\right)$ becomes quicklime $(\mathrm{CaO})$, through loss of carbonic acid $\left(\mathrm{CO}_{4}\right)$; and, at the same time, all carbonaceous materials are burnt out, and the color, when it is owing solely to these, becomes white.
2. Magnesian Limestone. Dolomyte.-Carbonate of calcium and magnesiam, but not distinguishable in color or texture from ordmary limestone. The amount of magnesime carbonate aftorded by analyses varies from a few per cent. to that of true dolomite ( $1.5 \overline{0}$ ).

Much of the common limestone of the United States is magnesian. That of St. Croix, Wisconsin, tho " Lower Magnesian," afforded Owen $42 \cdot 43$ per cent. of magnesium carbonate.

In some limestones the fossils are magnesian, while the rock is common limestone. Thus, an orthorrors, in the I'renton limestone of Bytown, Canada (which is not magnesian), afforded T. S. Hunt, Calcium carbonate 560 , magnesium carbonate $3 i * 80$, iron carbonate 595 $=99 \cdot \pi \%$. The pale-yellow veins in the Italian black marble, called "Egyptian marble," and "portor" (soe above), are dolomite, accorling to Hunt ; and a linestone at Dudswell, Canada, is similar.
3. Chalk.-A white, carthy limestome, easily leaving a trace on a board. Composition the same as that of ordinary limestone.
4. Marl-A clayey or earthy deposit containing a large groportoon of calcium carbonate-sometimes 40 to 50 jer cent. If the marl consists largely of shells or fragments of sholls, it is called shell-marl.

Marl is used as a fertilizer; and other beds of clay or sand that can be so used are often in a popular way called murl. The "Green sand " of New Jersey ( $p .429$ ) is of this kind.
5. Travertine.-A massive limestone, formed by deposidion from calcareous springs or strams. The rock abounds on the river Anio, near Tivoli, and St. Peter's at Rome is constructed of it. The name is a corruption of Titurtine. It oecurs in the Yellowstone Park, along liardiner's River.
6. Stalagmite.-See page 216 .

## 2. Crystalline Linestone.

1. Granular or Crystalline Limestone (Marble).-Limestone having a crystalline-granular texture, white to gray color, but often of reddish and other tints from impurities. It is a metamorplkic rock; it was originally common limestone; it becane crystalline under the action of more or less heat; in
the process all the fossils present were ohliterated, execpt in some cases of partial metimorphism. Its smpurities are often mire or tate, tremolite, white or gray pyroreme or scapolite: sometimes serpentine, thronge combinatoon with which it passes into ophiolyte (p. 45:3) ; oceasionally chondrodite, upulite, corumdum.

Vantertes.-a. Stuturry murble; pure white and fine qramed
 mottled of varions colors, and, when gond, free wot only from iron in the form of prite, but also from iron or manganese in the state of carbonate will the calcinm, and also from all arcessory minerals, even those not liable to alteration, and expecially those of greater hardness than the marble which would interfere with the polishinge. e. Ferd-
 cryatalizations of the white varicty of hornblende called tremolite.
 through it. g. (\%heritir: contains disseminated seates of chlorite. h. Thomprofitir; contains disseminated chondrodite in Jarge or small yellow to brown grains.

White and grayish-white marlle is abundant in Western Now Encland, and Southeasturn New Yorls (Westhester Connty). The texture is less coursely crestalline in Vermont than in Massarhusets, the crestallization of the limerntone as well as of the associated schists increasing in coarseness from the morth to the simath, wr rather somthsouthwest, which is the trend of the limestone belt. Fine marbes are quarried in Dorent, West Rutland, Pittsford, aud other places in Vermont, and the lest of stathary marble occurs abondantly in littsford. The whifent marble of hithand is not as firm as that mothed with gray, owiur apparently to the fart that it was made white by the heat that crystallized it burning out any carbonaceons material ; while at Pittsford. 16 miles to the north of Ruthand, it is rery firm, and is white, probably, because it was made with less heat from a whitrer limestone. In Vermont, the best quarries ocrur where the strata stand at a high angle. the layers in such regions were subjected to great pressure in the upturning that gave them this position, and this pressure has soldered many layers together in oue that are separate where the preswure was less; consequently blocks as large as an ordinary hoose might be ohtained at some of the quarries. (iond marble is atio quarried in Pomuryania, Maryland, and Temnessee (One of the most beautiful marbles from deposits of crystalline limestone in the Tinited States, is the mottled reddish brown from East Temmessee, and mainly from Knox and Hawkins comntios. Another handsome marble is the mottled red of Burlington, Vt, from the semi-crystalline Winooski limestone; and a still finer the deeper red (or cherry red), mottled and veined with white, of Swanton, Vt., from the same limestone on th: northern borders of the State.

The Carrara marble of Italy, the Parian, of the island of Paros (the birthplace of Phidias and Prasiteles, and the Pentelican, from quarries near Athens, Greece, are examples of crystalline limestone. The Carrara marble varies in quality from coarse to true statuary marble, and the best comes from Monte Crestola, and Monte Sagro. Out of
the 500 quarries only 20 furnish stone for the sculptor. The amount of marble taken out from the quarries in 1876 , was 120,000 tons, valued at $\$ 2,400,000$; and of this 40,000 tons came to the United States. The (ipolin marbles of Italy are white, or nearly so, with shadings or zones of green talc.
2. Dolomyte-Not distinguishable by the eye from grannlar limestonc.

Part of the marbles ahove referred to are dolomste. This is the case with that of Westchecter County, N Y., that of Canaan, Connecticut, and of Lee and Stockbridge, Massachusetts.

## II. Crystalline Rocks, exclusive of Limestones.

The crystallino pocks may be ristributed arcording to then composition int the following series or groups. Lach, excepting the first, embraces both metamorphic and eruptive rocks.

1. Siliceous rocks. The kinds consisting mainly of guartz or opal are here included. The first of those mentioned, page 43t, is intermediate between the fragmental and metamorphicerrytalline rocks. The opal material is a chemical deposit. The chert of redimentary formations is believed to be mainly tripolite ronsolidated through the solution of a part of its material by the permeating waters and its subsequent desposition-itripolite or diatom beds being matr chicfly of opal-silica which is readily soluble in 1:ate slightly alhaline.
2. The Mica and Potash-Feldspar series. These are em nently alkali-yicheng rocks, both the mica, whether muscorite, biotite, or lepidomelane, and the feldspar, whether orthoclase or microcline, affording on amalysis, as explained on pare 411, much potash, and the feldepars often also some soda. The soda feldepar, alhite or oligoclase, is a common aecessory ingrodient. The series shades off into a rock that is chicfly feldspar, and another that is chiefly mica; and in these two extremes the amount of jotash yiolded is abont the same. Moreover, as leucite is essentially a potashfeldepar in ratio and composition (see page 411), rocks, consistiner chiefly of leucite, without proxene or hormblende, belong with this reries. Muscorite and biotite commonly occur together, the formation of biotite having been determined by the presence of some iron oxide in the original material from which it was made. The mica is sometmes a hydrous species (page 313).
3. The Mica and Soda-lime-Feldspar series. Thesc granitoid rocks are equally alkali-yielding with those of the true granite group, but the alkali is mainly solla. The nephelite (elleolite) rocks not hornblendie are here included, although they eontain in general some microline or orthoclase.
4. The Hornblende and Potash-Feldspar series, or the Syenyte group. In this series, the mica of the granite series is replaced by the non-alkaline mineral, hornhende. Transitions between the granite and syenyte rocks are common-a bed that is true mica schist often becoming hombladic; the same specimen may have moxa and homblende erystals together, or parallel mica and homblende layers, and then not far beyond the selist may be a purely hormbende rock: and so there are similar transitions in other parts of the two series. This transition in a stratum of mica schist, a metamorphic rock, indicates merely that the mulded or sedimentary stratum, out of which the mica schist was made, had a diminished proportion of alkali in some parts. and, in still others, a complete ahsence of alkali-which is just such a variation as night be looked for in oceanic sediments, as they sprad over a wide region. The hornhlende may be replaced by epidote, another irm-hearing mineral.
5. The Hornblende and Soda-lime-Feldspar series The soda-lime-feldspars, in this series, may be either of the triclinic species, from allite to anorthite.
6. The Pyroxene and Soda-lime-Feldspar series. The soda-lime-feldspars are the same as in the preceding. Quartz is very rarely present, except in traces. Potash replaces soda in amphigenyte.
7. Pyroxene, Garnet, Epidote and Chrysolite rocks, containing little or no Feldspar.
8. Hydrous Magnesian and Aluminous rocks.
9. Iron Ore rocks.

## 1. SILICEOUS ROCKS.

1. Quartzyte, Granular Quartz.--1 siliceous sandstone, usually very firm, occurring in regions of metamorphie rocks. It does not differ essentially from the harder siliceous sandstomes of other regions. Conglomerate beds are sometimes includer.

Varteties.-a. Massive. b. Schistose. c. Calcareous; sometimes rontains disseminated calcite which, where the rock is exposed to weathering, is removed and leaves the rock loose in texture, or cellu-
lar. d. Micaceous. e. Aydromiraceous; it graduating at times into hydromica or mica slate. f. Feldspothir, sometimes porphyritic (tho rock Arkose) ; this variety occurs north of Lenox, Mass., and when it loses its feldspar, it becomes cellular, like buhrstone; ; has been used for millstomes. g. ( $\ddagger$ nciswoid ; containing some mira and feldspar in layers, and so graduating toward gneiss. h. Aulalusitic; coutaining andalusite, as in Mt. Kearsarge (Hitcheock) i. Tourmolinir; ; containing tourmaline. The vicinity of the great crystalline limestone formation of the Greeu Mountain region, in Western New England (in Vermont to the west of the principal ridge of the Green Mountains), includes strata of quartzyte of great thickness, and high summits in Bennington, and to the uorth, and also south, consist of it. In several paces the quartzyte strata graduato into, and also alternate with, bydromica or mica miates, and in Massachusetts and Connerticut, with gueiss. Between Bernardston, Mass., and Vernon, Vt, guartzyte occurs in large beds. and also graduates into gueiss and hornblembic rocks. Quartzyte exists also in the central part of Southern New Ilampshire, in the Archaran area of Wisconsin, and in the Rocky Mountain region. j. Nomaculilie-quartzyte, or Notarulyte ( Whetstone'). Novaculvte is only in part an extremely fine-grained siliceots rock. Of this nature is the varioty from Whetstone or Ilut Spring Ridge, in Arkansas. This, ridge, 20 feret in height above the lfot Spring Valley, is made up of the heautiful rock, "equal," says D. I). Owen, "in whitenoss, closeness of texture, and subdued waxy lactre, to the most compact forms and whitent varieties of ('arrara marble. Yet it belonge to the age of the millstone grit." Dr. Owen supposed it to have received its impalpable fineness through the action of the hot waters on sandstone. An analysis of the rock afforded him (Second Rep. Geol. Arkansas, 1860 . p. $2 \dot{4}$ ), Silica $98 \cdot(1$, alumina 0.8 , potash $0 \cdot 6$, soda $0 \%$, moisture, with traces of lime, maguesia and fluorine $0 \cdot 1-100$. Ine states that alonge the southern flank of the ridge there are over forty hot springs, haviag a temperature of 100 F . to $14 \mathrm{~s}^{\prime \prime} \mathrm{J}$. Nolid masses from the fine rock have been got out weighing about 1,200 lbs. ; the coarse varicties are made into stones for bench toojs.
2. Itacolumyte.-Schistose, consisting of quarla grains with some hydrous mica; on account of the mica in the lamination, it is sometimes llexible, and is called flerible samdstone.

Occurs in the gold regions of North Carolina and Brazil, and diamonds are supposed to be sometimes comnected as to origin with this rock.
3. Siliceous Slate.-Schistose, flimty, not, distinctly granulan in texture. Sonetimes passes into micas slate or schist.
4. Chert.-An impure flint or hornstone ocrurring in beds or modnles in some stratified rocks. It offen resemhles folsyte, hat is infusible. Colors varions. Sometimes oölitic. Kinds containing iron oxide mraduate into jasper and clay ironstone ; and others, occurring as layers or no-
dules in limestone are whitish, owing to the limestone material they contain. Chert sometimes contains carities which are liued with chalcedony or agate, or with quartz crystals.
5. Jasper rock.-A flinty siliceous rock, of dull red, yellow, or greencolor, or some other dark shade, breaking with a smooth surface like flint. It consists of quartz, with more or less clay and iron oxide. The red contains the oxide in an anhydrous state. the yellow in a hydrous; on heating the batter it turns red.
6. Buhrstone.-A collular siliceous rock, flinty in texture. Found mostly in comection with Tertiary rocks, and formed apperently from the action of siliceous solutions on preaxisting fossiliferous beds, the solutions removing the jossils and learing cavities.
Buhrstone is the material preferred for millstones. The bulerstone of the vicinity of Paris, France, has long been largely exported for this purpose Good buhrstone is obtained also from the Tertiary in Greenville Distrint, south ('arolina, 100 miles up the Saramah River.
7. Fioryte. (Siliceons Sinler, I'earl Ninter, (iralserite.)-Opal-shat, in compact, porons, or concretionary forms, often pearly in lustre : made by depostion from hot siliceous waters, as about geysers (figeserate), or throngh the decomposition of shliceous minerals, especially about the fumareles of roleanic regioms.

Geyserite is abundant in Yellowstone Park, and about the Iceland geysers; after long exposure it crumbles down and becomes changed to urdiuary silica, or quartz.

## 2. MICA AND POTASII-FELDSPAR SERIES.

1. Granite.-Consists of quartz, orthoclase, and mica, and has no appearance of layers in the arangement of the mica or other ingredients. $G==2-2 \cdot 8$. The quartz is usually grayish-white or smoky, glassy, and without any oppearonee of clectrege. 'The feldepuar is commonly whitish or fleshcolored, and may be distinguished from the quartz by its cleavare surfaces, which reflect light brilliantly when the specimen is held in the sunlight. The miea is usually in small bright scales, either silvery, brownish-blatek, or back in color, and the point of a knife earefully used will casily eplit them into thimer scales; the silvery mica is muscovite, but sometimes of the allied hydrous kinds, margarodite or
damourite, and the black mica is usually biotite, though oceasionally tho allied, more iron-bearing, species, lepidomelane. Oligoclase or albite is very often present.

Occurs both metamorphic and eruptive. Metamorphic Granite may often be seen graduating into gneiss, or lying in beds alternating with gueiss.

Vanimtime.-- There are, d. Muscovite cranites; B. Biotite granites ; (. Muscovite-and-biotite granites, the last much the most common. The mo-t of the following varieties occur under vach exeept the hornWhodic, which is usually a Biotite, or Muscovite-and-Biotite, granite. 'There is also, D. Hydromica-granite. a. Common or (ordinuty yranite; the color is grayish or flesh-rolored, according as the feldspar is white or reddi-h, and dark gray when much black mica is present. Granite varies in texture from fine and even, to contro'; and sometimes the mica, feldspar, and quartz-especially the two former-are in large crystalline masses. An average granite (mean of 11 analyses of Leinster granite, by Haughton) affords Silica 72.07 , alumina 14.81 , iron protoxide and sesquioxide $2 \cdot 52$, lime $1 \cdot 63$, magnesia $0 \cdot 33$, potash $5 \cdot 11$, soda $2 \cdot 79$, water $1 \cdot 09=100 \cdot 85$. b. Porphyritie gronite; has the orthoclase in defined crystals, and may be (a) small joryhyritic, or (/;) large porphyritic, and have the base ( $\gamma$ ) coarse granular, or ( $\delta$ ) finc, and even subaphanitic. e. Allitic gromite; contains some albitr, which is usually white. d. Otigoclese grunte' Miorolite) ; contains much oligoclase. a. Mirrocline granitr; contains the potash triclinic feldsjar, miscocline. f. Ilornhendic granite ; contains black or greenish-black homblende, along with the other constituents of manite. g. Blach micurems granite; comists lareely of mica, with defmed crystals of feldspar (porphywitic), and but little guartz. h. Iolilic; containing iolite. i. (ilobulifirous grouite; contains concretions whieh consist of mica, "r of feldspar aud mica. j. Gilltastud fircuite: a granite in which there ore traces of stratifiention; \& wamars into
 cluse and quarta, with hat little mica; bat the quartz is distributed through the feldspar in forms looking like oriental characters.

A porphyritic granite, oceuring at the junction of the andalusite mica-argitive (page 411) of the White Momotain Notch, N. II., with the Mt. Willard granite, on the west side of Mt Willard, conformable with the bedding of the argillyte, has the argillyte for its base; and in it the orthoclase is in large well-defined crystals, and the guartz in double six-sided pyramids, both casily separable from the matrix; the layer is six to twenty fect thiek.

The distinctions as to linds of rocks betwren metamorphic and eruptive granites are not yet made nut. $\Lambda$ porphyritic raricty, having the hase fine.grained, ocrurs rast of Parkview Jeak, in the Rocky Mts., which, according to Hague, is cruptive and related to the trachytes of the region. The granite of Now England is for the most part metamorphic or in veins. The following are prominent regions of the granite quarries. In Maine: at Ilallowell, a whitish granite, sometimes a little gneissoid; at Rockport, whitish; at Clarke's Island, spotted gray ; at Jonesbury, flesh-red; also in the Mt. Desert region.

In New Hampshire, at various places, but most prominently near Concord, a fine-grained whitish granite. In Massachusetts at several points, especially in Gloucester at Rockport, a red granite. (The Quincy "granite" is a syenyte.) In Rhode Island, at Westerly, a fine-grained whitish granite. In Connecticut, at Millstone Point near Niantie, and at Groton, near Now London, a fine-grained whitish granite, at Stoney Creek, a pale reddish, but liable to large micaceous spots; at Plymouth, on thr Naugatuck, a whitsh granite, even and fine-grained, more easily worked than the Westerly.
2. Granulyte. (Leplinyle.)-Like granite, but containing no mica, or only traces. Metamorphie and ernptive.

Vameties.-a. Commen granulyte; white and usually fine granular, a common rock in Western Comecticut and Westchester Co., New York. b. Flesh colored; usually coarsely crystalline, granular, and flesherolored ; the coarse flesh-colored "qranite" of the Eastern or Front lange of the Rocky Mts., in Colorado, sometimes called Aplite. is partly of this kind ; it contains a little allite or oligoclase with the orthoclase. c. Gefrnetiferous. d. Ifernblendie; contaming a littlo hornblende-a variety that graduates into syenyte. e. Magurtiter; containing disseminated prains of magnctite, a kind conmon in Archsean regions, in the vicinity of the irou ore beds, oceurring in Orange Co., N. Y., and sonth in New Jersey, and also at Brewster's, lutchess (\%., N. Y., and in Kent and Comwall, Coun. if Giraphio (Prgmatyte) - like graphic granite, hat containing no mica. The coarser granulyte, especially that of veins, is often called pegmatyte when not graphic.
3. Gneiss.-Like granite, lut with the mien and other ingredients more or less distinctly in layers. Geviss breaks most readily on the direction of the mica layers, and henee its schastose structure ; in consequence of thas structure, many kinds maty be got out in slabs. It oftern graduates impurecpetibly into granite. Metanorphic.
Variemtes. -..-Similar to those under grauite. a. Porphyritic. b. Al. bitic. c. Oligoclase-bedring. d. Itornble'udec. e. Mícuctuas. f. Cilobuliferous. g. Epidotic. h. Garnetifcrous. i. Andalusitac; contains an dalusite in disseminatel crystals. j. Cyamtic; contains cyanite, a variety that has bren observed on New York Island, and also in Newtown, Ct., Bellows Falls and elsewhere in N. II. k. Graplitic; contains graphite disseminated through it. 1. Quartzose; the quartz largely in excess. m. Quartaytic ; consists largely of quartz in grains, being intermediate between quartzyte and gneiss, a variety occurring just northeast of Bernardston, Mass. Fig. 3 on page 415 represents, natural size, a small piece of the porphyritic gneiss of Birmingham, Conn.
Some gneiss is very little schistose, being in thick, heavy beds, granite-like, while other kinds, especially those containing much nica, are thin-bedded, and very schistose; the latter graduate into mica schist. The so-called granite of Monson, Mass., is a granitoid gneiss. Its gneissoid structure facilitates greatly the quarrying.
4. Protogine. Protogine-gneiss.-Coarse to fine granular, manite-like or wneissond in structure, and mostly the latter; of a grayish-whte to greenish-gray color ; consists of quartz, white or grayish-white, rarely flesh-red, orthoclase, a dark green mica and often ehlorite, with some greenishwhite tale, and white oligoclase. Metamorphice.

The dark green mica approuches chlorite, as shown by Delesse, in its very laren percentage of iron oxide ( $\mathrm{Fe}_{2} \mathrm{O}_{4} 2131$, Fe()503), but it Eave him only 090 of water, with 60 g of potash. Among accessory mincrals are hornblende, titanite, garnct, serpentine, magnetite. In an analysis of the protorine as a whole, Delesse obtamed silica 74.20 , alumina 1158 , iron oxide 241 , lime 104 , water $0 \cdot 97$, leaving $10 \cdot 01$ for potash, soda and magnecia From the region of Mont Blanc and other parts of the Swiss Alps.
5. Mica Schist.-Consists largely of mica, with usmally much quartz, some foldspar, and, on aceomet of the mica, divales casily into slahs, that is, is very sehistose. Usually both of the potash mieas, museorite amd hotite, are present, and the latier (hack mica) is commonly much the most abmadant. The eolors viry from silvery to black, areording to the mica present. Often crumbles easily; and roudsides are sometimes spangled with the mienscales. The dissememated scales or crystals of biotite are sometimes set transveraely to the bedinge. Metamorphice.

Tametres.-a. Gencissoid; between mica schist and gneiss, and containing much feldspar, the two rocks shading into one another.
 dalusitic. g. Frimolitix; containing fibrolite. h Tommaninir. i. Calcoreous: limestone occurring in it in oerasional beds or masses. j. Graphitic, or Plumbaginoms; the graphite being either in scales or impreguating gencrally the schist. k (ourtuse: consisting largely of quartz. 1. (undetzytif; a guartyyte with more or less mica, rendering it schistose. m. Sperular, or ltabyrite ; containing much hematite or specular irnn in bright metallic lamelle or seals. In fine-grained mica schist, the scales of mica are sometimes scarcely visible without a lens.
6. Hydromica Schist.-A thin-schistose rock, consisting either chicfly of hydrons mica, or of this mica with more or less quartz; having the surface noarly smooth, and feeling greasy to the fingers; pearly to faintly glistening in lustre; whitish, grayish, pale greenish in color, and also of darker shades. For analyses of hydrous micas sec page 313. Mr.amnmbic

This rock used to be called talcose slote, but, as first shown by Dr. C. Dewey, it contains no talc. It includes Parophite schist, Damourite slate and Sericite slate (Crlanz-Schiejer and Scricit-sehiejer of the Germans.)

Varheties.-a. Ordinary ; more or less silvery in lustre. b. Chloritic ; contains chlorite, or is mixed with chlorite slate, and has therefore spots of olive-green color; graduates into chlorite slate. c. Garuetife rous. d Pyritifcrous; contains pyrite in disseminated grains or crystals. e Mragnctitic; contains disseminated magnetite. f. Quartzytic; consists largely of quartzytu, or is a quartzyte rendered schistose and partly pearly by the presence of hydrous mica, as is well seen in a ridge northeast of Rutland, Vermont, which consists partly of quartzyte and partly of hydromica schist.
7. Paragonite Schist.-Consists largely of the hydrous sola mica called paragonite (p. 314 ) ; but in other eharacters resembles hydromica sehist. Metamorphice.
8. Minette.-Brown to hark, finc-rianmed, compact, not mistinctly schistose ; consisting of biotnte (areording to the deseription and andysis of Delesse) and orthorlase; (antains also a litte homblende. Oceurs in heds in the Voseres, Franco, aseonated with mranite, syenyte, amd other crystallime rocks. Sometimes feebly porpliyritic and smallroncretjonary, the concretions comsisting manly of orthoelase. Mabo eraptive by I Elesse, and metanorphic by some later anthors. Approaches argillyte in appet.
9. Greisen.-Massive, withoutschistose structure. A mixture of emamular quartz and mioa, in seales. The mica may be museovita, lepidnlite, or biotate. It is a granite with the feldsuar left ont, and oecurs in rexions of enciss, granite, or quartzyte, and sometmes graduates into these rochs. Metamomphic.

Occurs in characteristie form at Zinnwald, in the Erzgelbirge, where it sometimes containe tin ore as an accessory ingradient, and is freguently penetrated by veins of tin; also in the tin ore regions of Schlackonwah and Cornwall. Occurs in the region of quartayte, hornblendic rocks and gneiss, of Upper Silurian age, between Bernardston, Mass, and Vernon, Vt., within three miles northeastof the former place, and also near Vernon; but at this place it contains usually a jittle hornblende, making it a very tough rock, and is intermediate between the quartzyte, hornblendic rock and mica schist of the region.
10. Mica-Argillyte or Mica-Phyllyte.-Inch'des the part of argillyte (p. 428 ) which has the composition nearly of a hydrous mica, like that of the White Mountain Notch, where much of it is andalusitic. Analysis of this White Mountain rock, by Hawes, afforded Silica $46 \cdot 01$, alumina $30 \cdot 56$, iron sesquioxide $1 \cdot 4.1$, iron protoxide $6 \cdot 85$, manganese protoxide
$0 \cdot 10$, magnesia $1 \cdot 42$, soda $1 \cdot 12$, potash $6 \cdot 66$, titanium dioxide $1 \cdot 91$, water $4 \cdot 13=100 \% 2$. (Compare with analyses of hydrous muscorite, or margarodite.) Metamorphic.
11. Felsyte. Quartz-Felsyte. (Luryte, I'etrositex.)-Compact orthoclase, with often some quartz intimately mised: fine granular to flint-like in fracture; sometimes contains ohgoclase. Colors white, crayish-white, red, brownish-red to black. $\quad \mathrm{G} .=2 \cdot 6-2 \cdot 7$. Both metamorphic and eruptive.

Vabietifs.-There are two sections, I. Felsyte, and II. QuartzFelsyte, and under each occur the following varieties. a. P'orphyyitio, Felsytc, or Porphyry; containing the feldspar in small crystals distributed through the compact base; color red and of other shades; called sumetimes (luartz-purphyry, when the base is a quartz felsyte. b. Conglomerete felcaytr ; containing pebbles, as at Marblehead, Mass., and in the White Mountains. e. Oligoclusc-batring; containing this triclinie feldhar intimately blended with the orthoclase d rilluhar or amyydaluitul. e. Elcomyle: essentially a quartzose felsyte. of gray, bluishgray to brown and red colors, and often containiug disseminated grains or crystals of quartz and feldspar, and some oligoclase ; some compact slate-rock has the same compositom. Occurs in Cornwall.

The metanorplue and eruptive kinds are not casily distinguishod. The former occurs associated with sedimentary strata, and of en costains pebbles or other evidence of fragmental origin; while the latter is frequently in dikes, that is, fills the fissures through which it was ejected. Some of the eruptive felsyte has nearly the aspect of trachyte, with which rock it is identical in composition. Much of the red porphyry contains hornblende with the feldspar of the base, and has the constitution of dioryte (p. 447).
12. Porcelanyte. (I'orctain Jasper.) - I haked clay, having the fracture of flint, and a gray to red color: it is somewhat fusible before the blowpipe, and thus differs from jasper. Formed by the bakine of clay-beds, when they consist largely of teldspar. Such clay-beds are sometimes baked to a distance of thirty or forty rods from a trap dike, and over large surfaces by burning coal beds. Metamorphic.
13. Trachyte. Quartz-Trachyte. -Consists mainly of feldspar, which is partly in grassy crystals, either sanidin or oligoclase; aut, owing to the angular forms of the glassy feldepar and the porosity of the rock, the surface of fracture is rough, whence the name from the dreek trachus, rough. Sometimes contains disseminated quartz, and is then quartz-fachyte. Color ash-gray, greenish-gray, brown-ish-gray, but sometimes yellowish and reddish. $G .=2 \cdot 5-$ $2 . \%$ Besides the feldspar there are distributed, somewhat sparingly, through the mass, in many kinds, minute needles crystals or scales of biotite, magnetite; some-
times nepholite, hä̈ynite, tridymite. Apatite exists in the rock in mieroscopic forms, and there is also more or less of the rock in a glassy state. Sometimes contains augite, and has a higher specific gravity. Quartz-trachyte has often nearly the composition of granite in which there sis litte mica. Fruptive only.

Varieties.-The two principal divisions under each, trachyte and quartz-trachyte, are : A Sunidin-trachyte, in which the mass is chiefly sanidiu; and B. Oligoclasc-trarhytc, or Domyte, in which it is partly oligoclase ; but the two graduate into one another. Both occur porphyritie with tabular crystals of feldspar; and in the latter (as at the Drachenfels) the tables are sanidin. They graduate into vosicular or seorinctomes trachyte.

Trachytr, according to Reyer and Suess, occurs in the region of the Eugunean Hills of Tertiary. Cretaceons and Jurassic age; and the felsyte of Paleozoic age is often hardly distinguishable from it, while ilentical with it in composition.

Trachytc and quartz-truchyte graduate also into felsyte-like volcanic rocks of like constitution, porphyritic or not so. The Jatter sometimes shades into rocks of semi-glassy nature called
14. Pearlstone. when somewhat pearly in lustre; Pitamstone when having a putch-like lustre; and these into the glasey voleanic material called obsidion. These glassy rocks of en contam spherules which are concretions consisting of fehspar with some quartz. Pomice is a light, porous, foldspathic seoria, with the pores rapillary and pamallel. Ordmary obsidian, that consists chiedly of foldspar, and is hence nearly free from irom, belongs here; the rest of it belonging with the augitic igneons rocks.
15. Leucityte. - 1 grayish rock consisting chicfly of lencite in a felsitie state, with disseminated lencitecrystals. Ocents at Point of Rocks, Wyoming Territory, according to King and Zirkel. It differs from amphigenyte, in containing no pyroxene, or only traces of it.

## 3. MICA AND SODA-LIME-FELDSPAR ROCKS.

## I. NOT CONTAINING NEPITELITE.

1. Kersantyte.-Fine-grained ; consists of hatite and white oligoclase, with some yuartz, and frequently some homblende in needles, and magnetite ; sometimes porphyritic. Analysis afforded Delesse $58 \cdot 0$ per cent. of silica, and $63 \cdot 88$ of silica for the oligoclase. From Visembach and St. Maric-anx-Mines in the Vosges, the Saxon Erzebirge, and Nassaa.

Kersanton is a similar rock, from near Brest, and from Quimper in Irittany, where it is used for buildings. It contaius no hornblende, aud affords about 53 per cent. of silica. Both have been called micadioryte (Glimmer-Diorite), ulthough not hornblendic rocks. (See pago 425.$)$
2. Kinzigyte--Granular-crystalline to compact and sehistose : consists of biotite, oligoclase, garnet, withont quartz, and contains, as accessorres, microcline, jolite, and fibrolite. Affords in analyses about 44.5 jer cent. of silica. From Kinzig. north part of black Forest.

## 11. CONTAINING NEPITELITE.

1. Miascyte.-(iranitoid to schistose, and consisting of microcline, massive ucphelite (choolite). sodilite, hotite, along with some guartz, and often some zirenn. pyrochhore, monazite and other minerals. $A$ related nophente rock oecurs on Pic Island, Lake Superior. Nancd ly (i. Rose, from Miask in the Inmen Mountans, where it has a wide distrihution. Metamorphic.
2. Ditroyte.-A coare to fine-grainet rock, consisting of microctine, nephetite (elaolite), and somalite. From Ditro in Eastern Transylvania, where it is associated with symyte and mica schist and lies hetween there two rocks.
3. Phonolyte. (Chintstonc.)-Compact: of grayish, hue, and other shades of color: more or less echistose or slaty in structure; tough, and wally clinking under the hammer, like metal, when struck, whence the name. ( $i=2 \cdot 2 \cdot 2 \cdot \%$. Concists of glases feldipar (orthoclase or oligochase), with atephelite and some hornblende. (i. Jenzeh gives, for the composition of the Bohemian phomolyte, Samidin (glassy orthoclase) $53 \%$, nephelite $31 \%$, homblende 9.34 , gheme $3 \cdot 6 \%$, pyrite $0.04=98 \cdot 36$. Under treatment with acids the nophelite is dissolved out. Nosean and hatiynite occur in some phonolyte. Eruptreonly.

## 4. HORNBLENDE AND POTASH-FELISPAR SERIES.

In this series the hornblendo is sometimes replaced by equdote, another anhydrous iron-bearing mineral, yielding on analysis httle or no alkali ; microcline is often present as well as orthoclase. The species granuate into kinds conristing almost solely of hornblende. Biotite is often presrat as an ancessory mineral.

## I. NOT CONTAINiNG NEPIELItE.

1. Syenyte. Quartz-Syenyte.-A granitoid rock consisting of hornblende and orthoclase, with or withont quarta. Some oligoclase is often present. The quartziferous rariety, or yuurtz-syengle, includes the syenyte of the obelisks and pyramids of Egypt. Lake that, the rock is often flesh-colored; bat whitish and grayish rarictios are also common. The Saxon syenyte, withoud quartz, afforded Siliea $59 \cdot 8.3$, alumina $16 \cdot 8.5$, iron protoxide $5 \cdot 01$, lime $4 \cdot 43$, magnesia $2 \cdot 61$, potash $65 \%$, soda $2 \cdot 44$, water $1 \times 29$, and $9 .=$ $2 . \mathrm{r}_{5}^{2}-\mathrm{x} 90$. Metamophic and eruptive. Similar ratietjes occur mader hoth divisions of syenyte.

Vanteties.-a. Porphypitic. b. Allitic; containing albite in addition to the constituents of true symyte. c. Oligorlese-beating. d. Micuccous; contaning disseminated black mica, which is usmally biotite, and sometimes lepidomelane. e. Gurnctifirons. f. Epidetic; containing disseminated ejpidote. The gray "granite" of Quincy, Massachusetts, south of Bostom, extensively quarried for architectural purposes, is a quartzoyenyte. consisting of orthoclase. black to darl: green bornblemde, and quart\%, with some triclinic feldspar. Quartzsyenete orcurs also in the Frankenstein Cliff, five miles south of White Mountain Notch ; also in Mount (lhocorua, N. H.; in the Archsan of C'mada, at direnville, a red kind containing very lintle quartz, and a similar rock on Barrow Island. St. Lawrence, but comaining much quart\% and little hornblende. Syenyte without quartz is a rare rock in Eastern North America. It occurs in Nevada.
The mane Syenites is used for this rock by Pliny, who adds that it was also called "pyrrhoperilon"-this appellation, moning fire-red variegated, refermg to its being brightly spotted with rose-red. The quarries in the vicinity of Syene (the modern Assoun), whence the Egeyptians obtained this stone for their obelisks, columns, statues, sphinxes, sarcophagi, and the lining of their pyramids, are of great extent : and in oue of them there is an unfinished obelisk in its original position. They are situated to the south of Syene, and between that place and the island of Fhiloe. The rock consists chicfly of red feldspar and grayish quartz, with oligoclase, some black hornblende, and a little black mica. An analysis by Delesse obtained Nilica $70 \cdot 25$, alumina 160 , iron oxide with some manganese 290 , lime $1 \cdot \%$, expelled on ignition $4 \cdot 65$, magnesia and alkalies by loss $900=: 100$. More remote from Syene the rock loses its hornblende and becomes a granite.
The Scotch syenyte, so much used for monuments, is quartz-syenyte. It occurs both red and dark gray, and the former is closely like the Egyptian syenyte.

Werner applied the name "syenyte" to the quartzless syenytr of Plauenschen-Grunde, Saxony, an analysis of which is given above ta rock he afterwards called "greenstone"). G. Rose used the term for the quartz-syenyte. Other German lithologists have followed Werner, calling the quartz-syenyte, hornblende-granite. It soems best to draw
the line between the mica-bearing and the hornblende-bearing rocks, as here done, and to use the name syenyt. for the rock to which it was originally applied, as well as for the quartzless kinds
2. Syenyte-gneiss. - Like gneiss in aspect and smistoso structure; and also in constitution, execpt that hornblende replaces mica. Oceurs both with and without quartz, though wablly guartz-bearing. The varieties are nearly the same as under syente. Metamorphic.
3. Hornblende schist.-A schistose rock consisting of hornhende, with usually more or less quartz, lout somotimes almost wholly hornblende. Frequently contains (pidote, sarnet, magnetite. Metamorphic.
4. Amphibolyte.- $A$ very tough, granular-crystalline rock, consisting of homblende, and hardly schistose in structure. Color, greonsh-black to black. Metamorphic.

A Glauroph anitic varicty consists chicfly of the blue soda-hornblende, called glaucophane, with usually sume black mica. From Saxony Isle of Syra, Now Caledonia.
5. Actinolyte.- A tough, massive rock made chiofly of actinolite. (iravish areen. Metamorphic.
6. Unakyte-A flesh-colored granitoid rock eonsisting of orthoolase, quartz, and much yellowish-green epidote. From the Unaka Mountains, North Carolina, and Last Tennessee.

## II. CONTAINING NEPIElite.

1. Zircon-Syenyte.-A crystalline granular rock consisting of orthoclase, microcline, little hornblende, erystals of zircon, and some clmolite.
2. Foyayte- Coarse crystalline, grannlar to compact; consists of orthoclase, reddish-brown ucphelite (elmolite), in six-sided prisms, and blackish-green hornhlende. Occurs also porphyritic, and passes into an aphanitic varicty. From Mt. Foya and Picota, in the Province Algarve, in Portugal. Sitroyte (p. 444) is related, but contains very little hornblende.
3. HORNBLENDE AND SODA-LIME-FELDSPAR SERIES.

## I. NOT CONTAINING SAUSSURITE IN PLACE Of TLIE FELDSPAR CONSTITUENTS.

1. Dioryte. Quartz-Dioryte. (Gremstone in part.)-The triclinic feldspar, one of the acidic (rich in silica) species,
albite or oligoclase. Texture granitoid to fine-grained or compact. Color often grayish-white to greenish-white for the coarser kinds; olive-green to blackish-green for the finer. Very tough. $\quad \mathbf{x} .=2 \cdot 6-3 \cdot 0$. The quartz-bearing and quartz-less kinds constitute two sections having similar varicties. Dark-red, brownish-red, and dark-green porphyritic kinds, compact in base, have been called porphyryte. Metamorphic and eruptive.
Varieties.-a. Granitoil ; granite-like in texture. b. Compact or fine-grained, with the feldspar grains searcely distinguishable. c. Plophyritio ; the feldspar in crystals in a compact base. d. Slety ; a dioryte slate or schist, usually chloritic. e. Micaceous. f. Aphunitic (or Aphanite) ; nearly flint-like in texture.

An analysis of a dioryte of the Hartz afforded Silica 5465 , alumina $15 \cdot \%$, iron ses puioxide $^{2} \cdot 00$, iron protoxide 6.26 , manganese protoxide trace, magnesia 591 , lime 7.83 , potash $3 \%$, soda 2.90 , water and ignition $19(1)-100 \cdot 96$.

The antique red porphyry, or "rosso antico," figured on page 415, is an example of porphyritic dioryte. The crystals, according to the analysis of Delesse, are oligoclase, and have $(\mathbb{Q}=2 \cdot 67$, while the base has $G=2 \cdot 2(6 \pi$, it consisting of an intimate mixture of oligoclase and hornblende, with some grains of iron oxide. For the whole mass, aceordmg to 1)elcesse, (t. $=2.2613$, but after fusion, only $2 \cdot 486$. Distinct acicular crystals of hornblende occur in it. The rock is sometimes a breccia, being made up of angular fragments, either quite distinct from the mass or clse shading off into it, but all alike porphyritic. The Mt. Doklan, in which it occurs - "Porphyrites mons" of Ptolemy-contains also red syenyte similar to that of Syene, and a coarse red granite. The "porphyrite" of Ilfeld, of Schonau in Bohemia, and the " quartz-porphyrite" of Loliwansk in the Altai are here referred.

Propylyte' and quartz-propylyte have the same constitution. The former is the prevailing igneous rock of the Washoe district tvicinity of the Comstock lode), in Nevada; it is a grayish-green rock. yielding, on analysis, 64 to 66 per cent. of silica, and containing, ulong with oligoclase, hornbleude, disseminated in minute points, and rarely also bintite (Zirkel).

Oplite, of the Pyrenees, is greenish black dioryte.
2. Andesyte. Quartz-Andesyte-Contains the felldspar andesite along with hornhlende. As in the preceding, the hornblende is sometimes changed to chlorite. Quartz-andesyte, or Dacyte, is a quartz-bearing variety. Both kinds occur in the Washoe district. Eruptive. Also metamorphic?

Banatite and Tonalite are like quartz-dioryte in most characters. but have the feldspar the species andesitc. Each contains some biotite, the latter much of it. Banatite is from the Banat, and Tonalite from near Tonale, in the Southern Alps.

Trachydoleryte (of Abich), a dark gray to reddish-brown rock, somewhat trachyte-like in aspect, is, in part, near andesyte, it consisting of
oligoclase or andesite and hornblende, with $\mathrm{G}=273-2.80$, and affording 55 to 61 per cent. of silica; it occurs in the Peak of 'leneriffe, on Liscanera I. near Stromboli, and on some parts of Etna. Another rock included under this name, found at Stromboli, Rocea Monfina, and Tunguragna in Quito, contains augite in place of hornblende, with olipoclase or labradorite, and is near doleryte. A third rock described under this name by Ludwig is angitic trachyte, the feldspar being sanidin. Trachyte graduates into andesyte, augite-andesyte, doleryte, as well as granite.
3. Labradioryte. (Lativadoritr-Diorytc. (rrepustme in part.) -The feldspar one of the basie (poor in silica) spectes, babradorite or anorthite. I'exture usually finc-grained, sometimes crypto-erystallinc. Color light grayjoh-green to dark olive-green, blackish-green or gray, and sometimes black. Very tough. $(x .=28-3 \cdot 1$. Olten contains chlomte amb magnetite. Often has asociated with it beds of serpentiue or ophiolyte. Metamorphic and cruptive.
Varieties.-a. Granular crystalline. 1. Compart, or fine-grained; of dark green color ; constituent minerals not distunct. c. Porphyritic ; the feldspar in whitish or greenish-white crystals diss minated through a finr-grained hase, making a greenish "porphyry ;" its crystals sometimes anorthite d. Pyroxenic ; containing some disseminated pyroxeme. e. Magnctitic ; containing magnetite or titanic iron. Occurs in the Urals; to the west of New Haven, Comn., both massive and porphyritie; in Littleton, N. H. A porphyritic variety of the rock near New Haven-a metamorphic rock-afforded Hawes, Silicat $48 \cdot 61$, alumina $17 \cdot 81$, iron sesquioxide $0 \%$, iron protoxide $8 \cdot 46$, manganone protuside 020 . lime $11 \cdot 16$, magne 4 ia 7 \% $\%$, sola $2 \cdot 7 \%$, potash $04 \pi$, water 1633 , titanium dioxide $1 \% 35 .=100 \cdot 47$; ( $\mathrm{A} .=3.01$. A compact non-porphyritic rariety from the same formation, collected on Stockel's farm, afforded Hawes, Silica 50.36, alumina $14 \%$, iron sesquioxide 248 , iron protoxide 833 , manganese protoxide 0.46 , maguesia $7 \cdot 62$, lime $11 \cdot 13$, soda 304 , potash 044 , water $0 . \%$, titanium dioxide $1 \cdot 70$, chromium oxide $0 \cdot 78=100 \cdot 89 ;\left(\begin{array}{rl} \\ \hline\end{array}=3 \cdot 04\right.$. The crystals of the porphyritic variety, according to au imperfect analysis by E. S. Dana, consist of anorthite.
4. Corsyte.-A granitoid rock, consisting chiefly of anorthite and hornblende, with some quartz and biotite. From Corsica.

Teschenite is bluish-green, and chiefly consists of anorthite, hornblende, and angite, the hornble de sometimes in large black prisms ; also contains analcite. From Teschen, Austria.
5. Isenite.-Contains a triclinic feldspar and hornhlende, with much nephelite and nosean, and some magnetite. From the Eisbach (Isena) district in the Westerwald, West Germany.

## II. BAUSSURITH-BEARING.

6. Euphotide. ( (tablro in part.) - $\Lambda$ grayish-whito to gray-ish-green, and sometimes olive-green rock, very tongh, having G. $=2 \cdot 9-3 \cdot 4$. (Jonsists of saussurite of whitish to greenish and bluish color, mixed either with smaragdite of emeraldgreen color, or with green to grayish-green diallage ; the diallage gencrally containing more or less hornblende, and the smaragdite, pyroxene. The saussurite is commonly of either the first or secoud kind mentioned on page 410 ; but the distribution of these kinds is not fully made out. Labradorite is rarely present locally in place of the saussurite. Metamorphic.

Varieties.-a. Diallagic; diallage the chicf foliated mincral. b. Smarayditic ; emerald-green smaragdite, the foliated mineral. c Micuceous; contains mica. d. Strpentinous; contains some serpentinea rock into which it often graduates. e. Garnetiferous. f. Schistose; especially so when tale is present. g. l'ariolitic; contains aphanitie concretionary spheroids of the saussurite mineral, as in the " Variolite de la Durauce," and of Mt. (denèvre, and asociated with ordinary euphotide; for which concretions Delesse obtained the composition Silica $56 \cdot 12$, alumina $17 \cdot 40$. chromium oxide $0 \cdot 51$, iron protoxide 7.79 , magnesia 3.41 , lime 8.74 , soda 3.72 , potash 0.24 , ignition $1.93=99 \cdot 86$, and the specific gravity $2 \cdot 923$. The variety obtained at Orezza is the Verde di Corsica, of decorative art.
Occurs near Lake Gencva, in Savoy ; at Mt. Genèvre in Dauphiny, ncur the boundary between France and Italy; at Allevard, in the northenstern part of Isere ; in the valley of the Saas, north of east of the Monte Rosa region ; in the Grisons; near Leghorn and Bologna, near Florence, at Mt. Impruneta, it being the (iranitone (page 450) of the Serpentine region ; on Corsica, in the Orezua valley; in Silesia; in I. of Unst. It is often associated with serpentine; and the serpentine and euphotide form beds in irregular masses among, and as a constituent part of, a series of metamorphic strata, which include green chloritic and talcose schists, limestone (which, at Mt. Genèvre, is of the Jurassic formation), and other rocks. For the Mt. Genèvre euphotide. Delesse obtained Silica 4500 , alumina and iron oxido 26.83 , lime 8.49 , magnesia, soda and potash (by loss) 13.90 , water and carbonic acid 6.78 , and for the saussurite the result stated on page 410. The composition is near that of a labradioryte, and the difference in the two rocks must have depended on the different conditions attending crystallization. The mixture of hornhlende and pyrosene in either foliated constituent, in connection with their mutual positions and structure, proves that part of the hornblende is altered pyroxene. The remark made on page 410 with reference to the production of the saussurite may apply also to the foliated hornblende, and therefore to the whole rock.

## 6. PYROXENE AND SODA-LIME-FELDSPAR SERIES.

1. Augite-Andesyte.-Contains the same triclinic feldspar as andesyte, but augite is present in place of hornblende. Amount of silica obtained in analyses about 55 to 58 per cent. Texture crystalline-granular to aphanitic; colors dark gray to greenish-black and brownish-black. G. $=2 \cdot 65-2 \cdot 90$. Eruptive.

Varieties.-There are two series: A. Ordinary, that is, without chrysolite, or only in traces. 13. Chrysolitic, clirysolite being in disseminated grains or crystals. Under each there are varieties: a. auhydrous; b. hydroux, or chloritic, and feeble in lustre; and c. amyglatuidal, as well as chloritic. Again, each of theso varieties may be porphyritic. To the hydrous rock, and especially the chrysolitic, the term Melaphyre is sometimes applied.

Quartz-Augite-Andesyte is described by Zirkel as ocrurring in Palisade Cañon, in Nevada Plateau; it contains yellowish-brown augite, some biotite, some grains of quartz. Silica 0.71 per cent.
2. Noryte. (Iyperyte, Iypersthenyte.)-A basic granitoid rock in part, consisting of cleavable labradorite with disseminated pyroxene, or a granular crystalline aggregate of the two minerals. The pyroxene is often foliated, and has been improperly called hypersthenc. In place of latradorite, the feldspar is sometimes andesite, and sometimes anorthite. Color, dull fleal-red to brownish-red, also dark-gray, to grayish-black. Tough. $G .=2 \cdot 7-3 \cdot 1$, varying with the proportion of pyroxene, which is sometimes small. Contains also magnetite or titanic iron.
The name Gabbro has been applied to this rock; also to a coarsely granular igneous rock, consisting chietty of labradorite and foliated pyroxenc, referred beyond to doleryte; to euphotide: and, by the Italians, formerly to serpentine. Ferber, in his "1Briefe" (1773), says (p. 98): (ruthro of Florence is the same as the rock called "shichsischen Serpentin, in Deutschland," that is, the serpentine of Zöblitz. Again, on page 330 , he says that Mt. Impruneta, seren Italian miles from Florence, consists of Gabbro, or the so-called Saxon serpentine, and he alludes to the nccurrence in it of diallage and amianthus, and the presence also "der rogenannto Granitone" "in horizontalou fichichten in den Gabbro-Bergen," which sometimes consisted "aus weissem Fohlspat, welcher grosse Parallelepipeden formirte," though usually containing diallage.

Vameties,-a. (ryranitudid; the feldspar in distinct cleavable grains or masses. b. Feldspothase ; the pyroxene feeble in amount. e. Chrysolition; contains disseminated chrysolite. d. Anorthutir, or Tractolite; anorthite replaces the labradorite.
Noryte includes the so-called hypersthenite of the Adirondacke, Canada, and Norway. It occurs also in the Laramie Mills, Colorado, a
kind which afforded, on analysis, Silica $52 \cdot 14$, alumina 29.17. iron oxide $3 \cdot 26$, magnesia 0.76 , lime 10.81 , soda 3.02 , potash 0.98 , ignition $0.58=100 \cdot 92$.
3. Hypersthenyte. - A rock resembling the preceding, consisting of clavable labradorite with true foliated hypersthene; from St. Paul's, Labrador, and some other localities.
4. Doleryte. (Basalt, Trap.)-Chief constituents, labradorite and augite, with magnetite, and sometimes anorthite. Often porphyritic, and the feldspar crystals may be anorthite. Amount of silica yielded on analysis usually 47 to 52 per cont. Texture crystalline-granular to aphanitic; and often, especially in the latter, having glassy particles among the crystallime, or even an unindividualized base or magma botween the crystalline grains-the variety called Basselt ; often coarse granular through the body of a dike, while aphanitic along its walls, and sometimes coutaining glassy portions in the lalter when not elsewhere. Oolors dark grayish to bluish-black, greenish-black, and brownishblack. $\mathrm{C} .=2 \cdot{ }^{\circ} \cdot 5-3 \cdot 1$. Eruptive ; also metamorphic.

It includes the larger part of the rock usually called tron, abundant in most repions of igneous eruptions ; constitutes tho "tray" ridges of the Connecticut Valley, the Palisades of New Jersey, and similar ridges in Nova Scotia and North Carolina; also in the Lake Superior region, and oxtensive beds of so-called basaltic rocks over the Rocky Mountain slopes west of the Front IRange. The rock of New Haven, Conn., from West Rock, afforded Siiica 5178 , alumina $14 \% 0$, iron sesquioxide 359 , iron protoxide $8 \%$, manganese protoxide 044 , marnosia 763 , lime $10 \cdot 70$, soda 214 , potash $0 \cdot 39$, loss by ignition 063 , phosphorus peutoxide $0 \cdot 14=9989$; $x .=303$. A hydrons or chloritic variety from Saltonstall's Kidge, near New Haven, afforded Silica $49{ }^{2} 8$, alumina $15 \cdot 92$, iron sesquioxide 1.91 , iron protoxide $10 \approx 0$, manganese protoxide. $0 \cdot 37$, macresesia $5 \cdot 99$, lime $7 \cdot 44$ soda $3 \cdot 40$, potash 0.72 , water 390 , carbon dioxide $1 \cdot 14=100^{\circ} \% ; G=2 \cdot 86$.

Vandeties.- There are two series: A Ordinany, B. Chrywlitic, and for the latter the name Pcridetyte has been usod. Each occurs a. ahhtirous; b. hydroms, or chlmituc, of feeble lustre; c. "myydaloibth, as well as chloritic; d. vesicultr, or scoriacous, as in doleritic or basaltic lavas. Spilite is amygdaloid.

Again, each of these varieties may be porphyritic. Again, the augite may be in distinct crystals.

A coursegrauular kind, having the pyroxene foliated, is sometimes called a/athoro.

This basic rock, doleryte, is often called, also, bassolt, especially when it has an unindividualized hase ; a specimen of this kind, from Nevada, is represented in fig. $\%$ page 418 . The name, amomesite, has heen usel for an aphanitic kind, but is unnecessary. The term diothes, is sometimes applied to dolerytes older than Tortiory It was formerly supposted that the former differed from the latter in being
chloritic, and afterwards in never containing glassy particles or an unindividualized base; but neither distinction holds.

The "antique green porphyry," or Porfido verde antiro, figured on page 415, in fig. 2, is a porphyritic rock of the composition of doleryte, the feldspar being labradorite, and the other chief constituent, augite, with also some chlorite, or viridite, which last is the source of the grecuish color. It is from the South Morea, between Lebetsova and Marathonisi. Delesse obtained, from the compact lase, Silica 53.55 , alumina $19 \cdot 34$, iron protoxide 785 , manganose protoxide 0.85 , lime $8 \cdot 02$, soda and potash $7 \cdot 93$, water $2 \cdot 67$. In view of its firmness, and its contrast in this respect with most chloritic doleryte, it, may be queried whether the rock is not a metamorphie doleryte (metadoleryte). It closely resembles the porphyritic labradioryte from the vicinity of New Haven, Conn. (which is chloritic and metamorphic), though differing from it in containing pyroxene instead of horublende. A similar porphyry is reported from Elbingerode in the Hartz, Belfahy in the Vosges, and Barnetjern near Christiania in Norway.
5. Eucryte.-A dojeryte-like rock consisting chicfly of anorthite and augite. Occurs compact, and as a lava. From Elfdalen, Norway.
6. Amphigenyte. (Leucitophyre.)-Contans augite, like doleryte, but leucite (called sometimes amphigene) replaces the feldspar. Dark gray, finc-grained, and more or less cellular to scoriaceous. $\quad(\mathrm{G} .=2 \%-2 \cdot 9$. The loucite is disseminated in grains or in 24 -faced crystals. Constitutes the lavas of Vesuvius and some other regions. Accessory mincrals, nephelite, biotite, chrysolite, sodalite, sanadin, labradorite and

Haüynophyre is an amphicenyte from Vulture, near Melfi, in which haüynite replaces much of the leucite.
7. Nephelinyte. (Nepheline-rloleryte.)-Contains augite, like doleryte, hut nophelite replaces the feldspar, or the larger part of it. Crystalline-granular ; ash-gray to dark gray. The nephelite is partly in distinct crystals.
8. Tachylyte. Hyalomelan.-Blackish glass, or pitchstone, made in connection with augitic inncous rocks or lavas; the former affords on analysis 49 per cent. of silica, and the latter 55.

This Doleryte-pitchstone may be porphyritic, or contain small graius of augite, or of chrysolite.
7. PYROXENF, GARNET, EPIDOTE, AND CMRYSOLITE ROCKS, CONTAINING lit'JLE or NO FELDSPAR.

1. Pyroxenyte.-Coarse or fine granular pyroxene rock.
2. Garnetyte, or Garnet Rock.- $\AA$ yellowish-white to green-
jsh-white, tough rock, consisting of an alumina-lime garnet. Q. $=3 \cdot 39-3 \cdot 49$. From St. Fruncis, Canada. The superior yellow noraculite or whetstone, of Vieil Salm, Belgium, has the constitution, according to A. Renard, of a manganesian garnet. Metamorphic.
3. Eclogyte-Compact and tough. Consists of granular garnet and hormblende, with grass-green smaragdite. ( $\mathrm{G} .=$ $3 \cdot 2-3 \cdot 5$. A related rock consists of reddish or hrownishyellow garnet, and black or greenish-black hornblende, with often some magnetite. Metamorphic.
4. Epidosyte.-Pale green to pistachio-green. Consists of epidote mised with quartz. Metamorphic.
5. Eulysyte. - Finc-granular, consisting of chrroolite with a diallage-like mineral and garnet. Forms a bed in gneiss near Tumaberg, Sweden.
6. Chrysolyte, or Chrysolite-Rock.-Yellowi-h to pale olivegreen, granular ; consisting ahost, wholly of chrysolite. Ci. $=3-3 \cdot 1 ; \mathrm{H}=5: 5-6$. Abundant in Macon ('ounty, N. Carolina; in part changed to serpentine. Metamomhic.

Dunyte is yellowish-green ; granular, and consists of chrrsolite, with some chronite. From Mount Dun, Nuw Zealand. Eruptive.
7. Lherzolyte-Greenish-gray ; erystalline gramlar. Consists of chrysolite, enstatite, whitish proxene, with chromespinel and sometimes garnet. From Lake Lherz, etc. Is it metamorphic?
8. Picryte--Mlackish-green to brownish-red ; crystallinegramular. Consists of chrysolite, with augite sometimes in crystals. Graduates into chrysolitic doleryte.
9. Limburgyte. - A semi-glassy rock, consisting of chrysolite and augite, with some marnetite. It is occasionally amygdalondal. Affords on analysis 43 per cent. of silica.

## 8. HYDROUS MAGNESIAN AND ALUMINOUS ROCKS.

Contain one or more of the hydrous magnesian minerals, chlorite, tale, serpentme, or the related hydrous alummous mineral, pyrophyllite. The fine-grained kinds are more or less greasy to the touch; and some of them resemble the hydromica slates.

1. Chlorite Schist.-Schistose ; color dark green to grayishgreen and greenish-black; but little, if any, greasy to the touch. Consists of chlorite, with usually some cuartz.
feldspar intimately blended, and often contains crystals (usually octahedrons) of magnetite, and sometimes chlorite in distinct seales or concretions. Metamorphic.

Varieties.-a. Ordinary. b. Hornblendic ; the hornblende ingrains or needles. c. Magnctitic. d. Tourmalimic. e. Garnetiferous. 1. Pyroxenic. g. Staurolitic. h. Epidotic. Graduates into argillyte.
2. Chlorite-Argillyte.-An argillyte or phyllyte consisting largely of chlorite. Metamorphic.
3. Talcose Schist.-A slate or schist consisting chiefly of talc. Nat common, except in local beds, most of the socalled "talcose slate" being hydromica schist (p. 440).
4. Steatyte, Soapstone (p. 55).-Consists of talc. Massive, more or less schistose ; granular to aphanitic. Color, gray to grayish-green and white. F'eels very soapy. Lasily cut with a knife. Metamorphic.

Varieties.-a. Coarse-gromulet, and massive or somewhat schistose. b. Fine-yranular: "French chaik." c. Aphunitic, or Linssclacrite; of grayish-white, greenish, brownish to black colors, from St. Lawrence County, N. Y., and Grenville, Canada.
5. Serpentine.-Aphanitic or hardly granular ; of darkgreen to greenish-black color, easily scratched with a knife, and often a little greasy to the feel on a smooth surface. Although generally dark green, it is sometimes pale grayish and yellowish-green, and mottled. Metamorpbic.
Varieties.-a. Noble; oil green and translucent. D. Common; opaque, and of varions colors. c. schistose d. Diallugir; contains green or metalloidal diallage. e. Chromiferous; contains chromite, a chromiun ore belonging to serpentine regions. f. Bustitic; contains bastite or enstatite. g. Garnetiffrous; contains garnet, as at Züblitz. h. Chrysolitic; contains chrysolite. i Brecriated; consists of united fragments (See also page 308.) Serpentine has been made by the alteration of chresolite beds, and of chondrodite and other magnesian silicates. A rock consisting of serpentine and saussurite is true Gabbro.
6. Ophiolyte (Verd-Antique Marble).-A mixture of serpentine with limestonc, dolomite, or magnesite, having a mottled green color. Often contains disseminated magnetite or chromite. Metamorphic.
Varietifs.-a. Calcareons; the associated carbonate being calcite. b. Dulomitic ; the associated carbonate, dolomite. c. Mrgusiftre ; the associated carbonate, magnesite. Either of these kinds may contain chromite or magnetite. Handsome verd-antique marble has been obtained near New Haven and Milford, Conn. A beautiful variety, hav. ing pure serpentine disseminated in grains or spots through a whitish calcite, occurs at Port Henry, Lissex County, N. Y., and is worked.
7. Pyrophyllyte and Pyrophyllite Slate.-Like the preecding in appearance and soapy feel, but having the composition of pyrophyllite (p. 306). The color is white and gray or greenish whitc. Occurs in North Carolina. One of the varieties from the Deep River region is used for slate pencils. Metamorphic.

## 9. IRON-ORE ROCKS.

1. Hematyte. (Specular Iron Ore).-Mematite (p. 1\%6), in motamorphio beds. Color iron gray, and lustre bright, metallic, but varying to red and jaspery. Has the hardness of crystallized hematite and its red streak. Constitutes beds of great thickness in Archoan regions and thinner beds in formations of later geological age; alternates with hornblendic, chloritic, micaceous, and gneissoid, and sometimes calcareous rocks, and often contains siliceons or jaspery layers.

Varieties -a. Trongray; the ordinary massive kind. b. Red; resembling a hard red jasper, into which it sometimes passes. c. (omtaining mavtite; the octahedral crystals of martite having originally been magnetite, and showing that they are changed to hematite by their red streak. d. Folated; sometimes called micaceous irou ore, in allusion to the foliation. e. Epidetic

In large beds in the Arehaan of Canada, St. Lawrence Co., N. Y., at Marquette, Northern Michigran, Missouri. At Nictaux, in Nova Scotia, in semi-metamorphic fossiliferous Devonian there is a bed six feet thick.
2. Itabyryte.-A mica schist consisting largely of hematite in lamme of bright metallic lustre.
3. Magnetyte. (Magnetic Iron Ore).-Magnetite (p. 1\%8), in metamorphic beds. Color won gray to grayish hack, and hustre metallic; never bright red. Strongly attracted by the magnet, and hence often separated from the gangue, after crushing it, by means of large clectro-magnets. Constitutes, like hematite, thick beds in Archaan regions, and thimer in rocks of other periods.

Varieties.-a. Massive. b. Aranular. c. Epidotic. a IIornblendic. e. Chloritic. f. Titanic. g. Chomdroditic; as near Brewster, N. Y., where chondrodite is the " prangue" of the are

Metamorphic magnetite constitutes thick beds in the Archæan of Canada, Northern New York, Orange Co., N. Y., Sussex Co., N. J., and occurs also in Virginia, east of the Blue Ridge, in Allermarle,

Essex, and Nelson counties, and elsewhere. Forms a small bed in the Upper Silurian of Bernardston, Mass., and in Devonian, at Moose River, in Nova Scotia.
4. Menaccanyte. (Titanir Iron Ore).-Resembles massive hematite, but consists chiefly of titanic iron (p. 188). Oecors in the Areham of Canada, as in the parish of St. Urbain, at Bay St. Paul, where the bed is nincty feet thick.
5. Franklinyte-Resembles massive magnetite, but consists of franklunte (p. 179), which differs from magnetite in contaning more or less zinc and manganese.

Occurs at Mine Hill, in Hamburg, N. J., and also at Stirling Hill, in the same region, constituting a bed of grat thickness. It is mixed with zinc ores, zincite and willemite. besides other minerals, and associated with granular linestone, in an Archæan region of hornblendic and gneissoid rocks.

For hon-metamorphic kinds of iron ores, see under Hematite (p. 176), Limontte (p. 181), and Smertee (p. 185). Beds of magnetite occur only in metamorphic regions.

## GENERAL INDEX.

Acadialite, 300.
Acanthite, 11 y .
Acmite, 247.
Actinolite, 249.
Aetinolyto, 446.
Adamantior spar, 193.
Adamite, $15 \%$.
Adularia, $27 \%$.
Agirine, Agyrite, 24\%.
Aischynite, 202, 260.
Agralmatolite, 306, 312.
Agrate 2336.
Aikinite, 136, 149.
Akanthit, $\%$ Acanthite.
Alabandite. $18 \%$
Alabast. r , 210 .
Albertite, 220 .
Albite, $27 \%$.
Alexandrite, 196.
Algodonite, 13 .
Alipite. 168.
Alisonite, near Covellitr, 133.
Allanite, 203, 203.
Allemontite, 101.
Allopalladium, 127 .
Allophane, 296.
Allophite, 318 .
Alluaudite, 191.
Alluvium, 4:9.
Almaudin, Almandite, 25\%.
Altaite, 149.
Alum, native, 198.
Alum shale, $4: 8$.
Alum stone, 198.
Aluminite, 199.
Aluminum, Compounds fluorides, $19 \%$.
Alunite, 198 .
Alunogen, 197.
Amalgam, 117, 128.
Amazonstone, 278.

Amber, 325.
Amblygonite, 44, 199.
Ambrite, 325.
Amethyst, $235,239$.
Oriental, 193.
Amianthus, 2 20, 308.
Ammonium alum, 108, 2Si.
Ammonium, Salts of, 230 .
Amphibole, 249 .
Amphibolyte, 446.
Amphigene, 271.
Amphigenyte, 452.
Amygraloid, 418, 451.
Analcite, Analcime, 69, 290.
Anatase, 451.
Anamesite, 163.
Ancramite, 159.
Andalusite, $2 x+$
Andesine, Andesite, 276.
Andesyte, 447.
Andradite, 258 .
Andrewsite, 18.5.
Anglesite. 150.
Anhydrite, 211.
Ankerite, 186, 220 .
Annubergite $=$ Nickel arsenate.
Annite, 266.
Anorthite. 44, 275.
Anthophyllite, 25.3 .
Anthracite, 327
Anthraconite, 217.
Antigorite, 308.
Antillite, 309.
Antimonate. ('alcium, 214.
Copper, 133.
I ead, 152.
Antimonial copper ores, 1:35, 136.
lead ores, 149.
nickel ores, 166.
silver ores, 119,120 .
Antimonite,

Antimony, Native, 100.
glance, $v$. Stibnite.
Apatite, 46, 48, 49, 67, 212.
Aphanesite, 139.
Aphrodite, 307.
Aphrosiderite, :319.
Aphthitalite, 227.
Apjohnite, 198.
Aplome, 258.
Apophyllite, 294.
Aquamarine, 252.
Aragonite, : 18 .
Aragotite, 324.
Arcanite, 2027.
Arfvedsonite, 250.
Argentine, 121, 216.
Argentite. 117, 121.
Argillyte, 428.
Arkansite, 16:3.
Arkose, 436 .
Arksutite, 197.
Arquerite, 117.
Arragonite, 218.
Arsenate, Calcium. 214.
Cobalt, 167, 168.
Copper, 139.
Iron, $14 \overline{5}$.
Lead, 152.
Uranium, $170,171$.
Zine, 156.
Arsemic, Native, 98.
Arsenic group, 98.
sulphide. 99.
White, 99.
Arsenical antimony, 101.
robalt, 165, 166.
iron ore, 175, 176.
lead ores, 149.
nickel, 165, 16 f .
Arsenide, Cobalt, 165, 166.
Copper, 135.
Iron, 175, 176.
Manganese, 189.
Nickel, 165, 166.
Arseniosiderite, 185.
Arsenolite. 99.
Arsenopyrite, 175.
Asbestus, $246,250$.
Blue, $v$. Crocidolite.
Asbolan, Asholite, 167.
Asmanite, 241.
Asparagus stone, 213.
Aspasiolite, 310.

Asphaltum, 326.
Aspidolite, 266.
Astrakanite, $v$. Blödite.
Astrophyllite, $266 i$.
Atacamite, 136.
Atopite, 214.
Auerbachite, 260.
Augite, 24.5.
andesyte, 450.
Augitic trachyte, 448.
Aurichalcite, 141, $15 \%$.
Auriferous pyrite, 173.
Auripigmentam, 90.
Automolite, 196.
Autunite, 170.
Aventurine quartz, 235.
feldspar, 279.
Axinite, 44, 204.
Azurite, 141.
Babingtonite, 247.
Bagrationite, $v$. Allanite.
Bultimorite, 308 .
Banatite, 44 7.
Barite, 220.
Barium, Compounds of, 220.
Barytes, 220 .
Barytocalcite, 22N.
Basalt, 451.
Basanite, 287.
Bastite, 309.
Bathvillite, 8:5).
Beaumontite, :04.
Bechilite, :212.
Renzole, 324.
Berthierite, 176.
Beryl, 46, 252
Berzelianite, 135.
Beyrichite, 16 .
Bieberite, 168 .
Biharite, 312.
Bindheimite, 152.
Bimite, 136 .
Biotite, 266.
Bismite, 102.
Bismuth, 101.
Bismuth glance, $n$. Bismuthinite.
Bismuth ores, 102.
carbonate, 102.
Bismuth nickel, 166.
Bismuth silver, 116.
Bismuthinite, 102.
Bismutite $=$ Bismuth carbonate.

Bismutoferrite, 250.
Bitter spar, $v$. Dolomite. Bitumen, 326.

Elastic, 324.
Bituminous coal, 327.
Bituminous shale, 428.
Black cobalt, 167.
copper, 137.
jack, 155.
lead, 107.
silver, 119.
Blende, $1,54$.
Blödite, 206, 227.
Blomstraudite, 170.
Bloodstone, 237.
Blue iron carth, 185.
copper, 133.
vitriol, 137.
Bodenite, 263.
Bog iron ore, 181.
manganese, 190.
Bole, Halloysite, 312.
Boltonite, 256 .
Boracic acid, 97.
Boracite, 206 .
Borate, Ammonium, 231.
Calcimm, 213.
Hydrugen, 98.
Iron, 18\%.
Marnesium, 206.
Sodium, 212, 227.
Borax. 227.
Bornite, 134 .
Borocaleite, 212 .
Boronatrocaleite, 212 .
Boron group, 97.
Bort, 103.
Bosjemanite, 198.
Botryogen, 182 .
Botryolite, 280.
Boulangerite, 149.
Bournonite, 133 .
Boussingaultite, 201.
Bowenite, 309.
Bragite, 260 .
Branchite, 324.
Brandisite. 320.
Brass, composition ef, 144.
Braunite, 189.
Bravaisite, 302.
Brecria, 426.
Bredbergite, 258.
Breislakite, v. I'yroxene.

Breithauptite, 106.
Breunerite $=$ Ferriferous Magnesite.
Brewsterite, 304.
Brittle silver ore, 119.
Brochantite, 138.
Bromargyrite, 121.
Bromic silver, 121.
Bromlite, 22:.
Bromyrite. 121.
Brongniardite, 120, 149.
Bronze, 144.
Bronzite, 244.
Brookite, 163.
Brown coal, $32 \pi$. hematite, 181. iron ore, 181. ochre, 181. spar, 219. stowe, 427.
Brucite, 204.
Brushite, 214.
Bucholzite, 285.
Bucklandite, 262.
Rulirstone, 437.
Buratite, 141, 15\%.
Cacholong, 240 .
(acoxenite, Cacoxene, 185.
Cadmium, Ores of, 159.
Cairngorm stone, 235.
('aking coal, :327.
(alaite, $v$. Callaits.
Calamine, 157, 296.
Calaverite, 115.
Calcite, 49, 50, 215
Calcium, Compounds of, 20i.
Cale spar, 215.
Caledonite, 149.
Callainite, 200.
Callais, Callaite, 200 .
(alomel, 129.
Canaanite $=$ White Pyroxene, 245.
Cancrinite. 270.
Cannel coal, 327.
Cantonite, near Corellite, $1: 3$.
Caoutchouc, Mineral, 324.
('apillary prrites, 164.
Carbonaceous shale, 428.
(arbonado, 103.
Carbonato, Ammonium, 231.
Barium, 221.
Calcium, 215, 218, 219.

Carbonate, Bismuth, 102.
Cerium, 208.
Coppor, 140, 141.
Iron, 185.
Lanthanum, 203.
Lead, 15:.
Magnesium, 207 , 219.
Manganese, 191
Sodinm, 239, 230 .
Strontium, 230
Uranium, 171.
Ittrium, 203.
Zine, 156.
('arbonic acid, 108, 423.
('arburetted hydrogen, $3: 1$.
Carnallite, 205.
Carnelian, 236.
Carpholite, :96.
(arrara marble, 433.
Cassiterite, 1 (i0).
('astor, Custorite, 249.
Catapleite, 295.
('ataspilite, 312.
('atlinite, 4: 4 ).
Cat's-eyc, 236.
Celadonite, 307.
Celestite, C'elestine, 293.
Cerargyrite, 120, 121.
Cerite, 291 .
Cerium ores, 201.
Cerolite, 309.
Cerussite, 152.
Cervantite, 101.
Chabazite. 300 .
Chalc:anthite, 137.
Chalcedony, 235.
Chaleocite, 133 .
Chalconlite, 307 .
Chalcolite, 170.
Chalomorphite, 296.
Chaleophanite, 189.
Chalcophyllite, 139.
Chalcopyrite, $1: 33$.
Chalcosiderite, 18.5.
Chalcosine, 18\%.
Chalcostibite, 136.
Chalcotrichite=Capillary Cuprite, 136.

Chalk, 215, 432.
Chalybite--Siderite.
Chathamite, v. Choanthite.
Chert, $2: 37,4 \% 6$.
Chessy Copper, $x$. Azurite.

Chesterlite, v. Microcline.
Chiastolite, 285.
Childrenite, 200 .
Chiolite. 197.
Chloanthite, 165.
( Chlor-apatite, 213.
('hlorasirolite, : 290 .
Chloride, Ammonium, 280.
Copper, 136.
Lead, 149, 153
Magnesium, 205.
Mercury. 129.
1'otassium, $2 \mathfrak{2} 4$.
Silver, 120.
Sodum, 224.
Chlorite: argillyte, 454.
Groap, 316.
schist, 453.
Chloritoid, $3 \geq 0$.
Chlormagnesite, $20 \%$.
Chloropal, 307.
(7hlorophaxite, 818.
Chlorophane, 208.
('hlorophyllite, 2(6), 215.
Chborotile, 139.
(herdneffite, 19\%.
Chondrodite, 281 .
( Chonicrite, 317.
Chromate, Lead, 150, 151.
Chrome yelluw, 151.
Chromic iron, 180.
Chromite, 180.
Chrysoberyl, 190
(hrysocolia, 142, 295.
Chrysolite. 255.
rock, 453.
('hrysolyte, 453.
Chrysoprase, 2:30.
Chrysotile, 308.
Churchite, 203 .
Cimolite, 307.
Cinmabar, 128.
Cinnamon stone, 25\%.
(ipolin marble, $4: 4$.
(litrine, 233).
Claudetite, 100.
( 'lausthalite, 149.
Clay, 429.
iron-stone, 177, 181, 186.
slate, 428.
Cleavelandite, 273.
Cleiophane, 1050.
Cleveite, 170.
(lingmanite, 319.
(linkstone, 444.
Clinochlore, 319.
Clinoclasite, 139.
(linohumite, 281 .
Clintonite, $v$. Seybertite.
Coul, Mineral, 327.
Brown, 328.
Canuel, 327.
Cobalt bloom, 167.
glance, 165.
Ores of 163.
pyrites, 164.
vitriol, 168.
Cobaltite, cobaltine, 165 .
Coccolite, 246 .
Coke, 328.
Collyrite, 996
Colophonite, 258.
Coloradoite, 129.
Colorados, $1: 1$.
Columbatess, 170, 183, 202, 203, 214.

Columbite, 183.
Columbium, 184.
Comptonite, 298.
Conglomerate, 426.
Connellite, 47 (f. 11), 138.
Cookcite, 314.
Copal, Fossil.
Copaline, ('opalite, 320.
Copiapite, 182.
Copper, Nativer, 131.
froth, 139.
glance, 132.
(xray, 135.
mica, 130.
nickel, 166.
Ores of, $1: 30$.
pyrites, 133, 134.
vitriol, 137.
Copperas, 182.
Coprolites, 213.
Coquimbite, 183.
Cordierite, 264.
Corneous lead, 153.
Cornwallite, 139.
Corsyte, 448.
Corundellite, 819.
Corundophilite, 319.
Corundum, 19:.
Cossaite, 314.
Cotunnite, 140.

Covellite, Covelline, 133.
Credncrite $=\mathrm{Cu}_{1} \mathrm{Mn}_{\mathrm{Z}} \mathrm{O}_{1}$.
Crichtonite, v. Menaccanite.
Crocidolite, 252.
Crocoite, ('rocoisite, 150.
Cronstedtite, 819.
Crookesite, 135.
Cryolite, 197.
Cryophyllite, 208.
Cryptolite, 203.
Cryptomorphite, 212.
Cubanite, 134.
Cube ore, 185.
Cubic nitre, 2:29.
Culsarecite, 317.
Cummingronite, : $2 \tilde{0} 0$.
Cuprite, 136.
Cuproscheelite, 212.
Cuprotungstite, 138.
(yanite, 286.
Gyanotrichite, 135.
(ymatolite, 893.
Cyprine, 261.
Daleminzite, 118.
Damourite, 31:3,
slate, 441.
Danaite, 175.
Danalite, 256.
Danburite, 204.
Datholite, Datolite, 289.
Daubreelite, 180 ).
Daubreito, $=$ Bismuth oxichloride.
Dawsonite, 201 .
Dechenite=-Lrad vanadate.
Degeroite, 315.
Delessite, 318.
Delvauxite, $n$ Infrenite.
Derbyshire spar, $\because 09$.
Descloizite,
Desmine, :303.
Deweylite, 309.
Diabantachronyn, 318.
Diabantite, 318.
Diabase, $45 \Omega$.
Diallage, Green, 246
Diallogite, $v$ Rhodochrosite.
Diamond, 103.
Dianite, v. Columbite.
Diaphorite $=$ Trimetric Freiesleb. enite.
Diaspore, 104
Dichroite, 264.
101.

Didymium ores, : $01,203$.
Dihydrite, 139.
Dinite, 324.
Diopside, 246
Dioptase, 141, $256,295$.
Dioryte, 416.
Diphanite, 819.
Dipyre, 269.
Disturrite, 320.
Disthene, 286 .
Ditroyte. 444.
Mog-tiooth Spar, 215.
Dolerophanite, $1: 38$.
Doleryte, 451.
pitchstone. 45?.
Dolomite, $207,21!$.
Dolomyte, 48?, 434.
Domeykite, 135.
Itomyte, 443.
Dreclite, 221.
Dry-bone, 158, 364.
Dudleyite, $3 \geq 0$ (
Dufrenite, 185.
Dufrenoysite, 149.
Dunyte, 453 .
Durancite, 199.
Juteh white, :201
J)ysanalyte, :02, 214

Dyserasite, 110.
Dysluite, 199 .
1)yworlile, 325.

Dysyntribite, 812.
Farthy robalt, 167.
Eederaite, 153.
Elogyte, $45 \%$
Fdelforsite, 245 .
Fdenitr. 251.
Edinctonite, age
Edwardsite, $v$. Monazite.
Ehlite, 139.
Ekrbergite, 269.
Fkmannite, 816.
Elrolite, 269.
Wlaterite, 824.
Flectro-silicon, 430.
Electrum, 110.
Elasite, 170 .
Embolite, 121.
Embrithite, $v$. Boulanger:te. Emerald, 252.

Uricntal, 193.

Eimerald, nickel, 168
Emery, 193.
Emerylite, 319
Emplectite, 136.
Enargite, 136.
Enceludite, v. Warwickite.
Enstatite, 244.
Enysite, 138.
Eosite, near Vanadinite.
Eosphorite, 200.
Epichlorite, 316.
Epidosyte, 453.
Epidote, 262.
Epistilbite, 302, 304.
Eysom salt, Epsomite, 205.
Erbium ores, 201.
Erdmannite, 296.
Erinite, 139.
Erubescite, 134.
Erythrite, 167.
Esmarkite, $2655,315$.
Fucairite, 118, 133.
Eurhroite, 139.
Euclase, 288.
Eucolite, ${ }^{5} 54$.
Eucrasite, 296.
Eucryte, 452.
Eudyalite, Eudialyte, 254, 260.
Fudnophite, 300.
Fukairite, r. Eucairite.
Eulysyte, 453.
Eulytite, Eulytine, 102, 256.
Eucosmite, 320.
Euphotide, 449.
Euphyllite, 314.
Eupyrchroite, 213.
Furalite, 31s.
Euryte, 442.
Euxenite, 202.
Fahlerz, $13 \overline{5}$.
Fahlunite, 2 (i.), 814.
Fairfieldite, 191.
Fassaite, 246
Faujasite, :300.
Fayalite, 256.
Feather rre, $v$. Jamrsonite.
Feldspar Group, 2'2d.
Felsite, 280.
Felspar, $v$. Feldspar.
Felsyte, 442.
Fergasonite, 202, 260.
Fibroferrite, $18 \%$.

Fibrolite, 285.
Fichtelite, $3 \geqslant 4$.
Fiorite, 240.
Fioryte, 437.
Fireblende $v$. Pyrostipnite.
Fire-marble, 431.
Fire-opal, 2339.
Fischerite, 200.
Flint, 237.
Float-stone, 941.
Flos ferri, 218
Fluellite, 197.
Fluidal texture, 413.
Fluocerine, : 0 :
Fluocerite, 202.
Fluor-apatite, 213.
Fluor, Fluorite, 208.
Fluor spar, 208.
Fluorides, Aluminum, 197. (alcium, 208.
Foliated tellurium, 149.
Fontainebleau limestone, 216.
Foresite, 304.
Forsterite, 256.
Fowlerite, 247.
Foyayte, 446.
Franklinite, 158, 179, 456.
Free-stone, 427.
Freibergite $=$ Argentiferous Tetrabedrite.
Freieslebenite, 120, 121, 149.
Frenzelite, 103 .
Friedclite, 256.
Gabbro, 449, 4:50, 454.
Gadolin, Gadolinite, 203, 263.
Gagates, 328.
Gahnite, 196.
Galena, Galenite, 121, 145.
Galmei, 157.
Ganomalite, 153.
Garnet, 256. rock, 452.
Garnetyte, 452.
Garnierite, 168.
Gastaldite, 252.
Gay-Lussite, 200.
Gearksutite, 197.
Gehlenite, ${ }_{\sim}^{2} 84$.
Qenthite, 168, 309.
Geocerite, 325.
Geocronite, 149.
Geomyricite, $3 \times 5$.

Gersdorffite, 166.
Geyserite, 240, 437.
Gibbsite, 194.
Gieseckite, 2\%0, 812.
Gigantolite, ${ }^{2} 65$ 315.
Gillingite, 316.
Girasol, 239.
Gismondite, Gismondine, "96.
Glagerite, 312.
Glasprite, v. Arcanite.
Glass, 416.
Glauber salt, 41, 68, 220.
Glauberite, 227.
Glaucodot $=$ Cobaltic Arsenopyrite.
Glaucolite, 269.
Glauconite, 307, 429.
Glaucophane, 252, 446.
Globulites, 416.
Gmelinite, 301 .
Gneiss, 439.
Gold, 109.
Goslarite, 156.
Göthite, 18\%.
Grahamite, 320.
Gramtuite, 30 .
Grammatite, 240.
Granite, 437.
(iranitone, 449, 450.
(iranular quartz, 435.
(iranulyte, 439.
Graphic granite, 438, 439.
tellurium, 118.
Graphite, 107.
Grastite, 819.
Gray antimony, $v$. Stibnito. copper, 135.
Green earth, 307. sand, 429.
Greenockite, 159.
Greenovite, 290.
Greenstone, $446,448$.
Greisen, 441.
Grindstones, 427 .
Grit, 426.
Grochauite, 319.
Groppite, 314.
Grossularite, $25 \%$.
Grünauite, $16 \%$.
Guadalcazarite, 100.
Guanajuatite, 102.
Guano, 213.
Guarinito, 291.
Qummite, $1 \% 0$.

Gurhofite, 219.
Guyaquillite, 325.
Gymnite, 309.
Gypsum, 56, 210.
Gyrolite, 293.
Haidingerite, 214.
Hair-salt, 205.
Halite, 224.
Hallite, 318.
Halloysite, 312.
Italotrichite, 182, 198.
Hamburg white, D21.
Harmotome, 301.
Harrisite, 133.
Hartito, $3 \geq 4$
Hatchettite, Hatchettine, 324.
Hatchettolite, 170, 214.
Hauerito, 188.
Hanreaulite, 191.
Hausmannite, 189.
Maüyne, Haüynite, 970.
IIauynophyre, 40̃.

- Maydenite, 301.

Hayesine, 212.
Heavy spar, 220.
Hebronite, 190.
Hedenbergite, 246 .
Hedyphane, 152.
Heliotrope, 237.
Helminthe, 319.
Helvite, ITelvin, :3G
Hematite, 176, 45\%.
Brown, 181.
Red. 176.
Henwoodite, 200.
Mercmite, 196.
Herderite, 199.
Herschelite, 301.
Hessite, 118.
Ifetarolite, 189.
Heterosite, 191.
Heulandite, 303.
Hisingerite, 315.
Hocrnesite, 207.
Homilite, 289.
Honey-stone, 201.
Ifopeite, 158.
Hornblende, 249, 251. schist, 446.
Horn quicksilver, 120. silver, 120.
Hornstone, 237.

Horse-flesh ore, v. Bornite.
Hortonolite, 256.
Houghite, 194.
Howlite, 212.
Huascolite, 125.
Hubnerite, 183.
Hudsonite, 246 .
Humboldtilite, ? 61.
Humboldtite, 289.
Humite, 281.
Hureaulite, 191.
Hyacinth, 259, 260, 284.
Hyalite, 240.
Hyalomelan, 459.
Hyalophane, 276.
Hyalosiderite, 25.
Hyalotecite, 153.
Hydrargillite, 194.
Mydraulic limestone, 217, 481.
Hydroboracite, 212.
Hydrocarbons, 320.
Hydrocerussite, 153.
Hydrochloric acid, 282
Hydrocyanite, 138.
Hydrodolomite, $2: 20$.
Hydrogen, 231.
Mydromagnesite, 204, 207.
Hydro-mica Group, 312.
Hydromica schist, 440.
Hydrophane, 240 .
Hydrophite, 309.
Hydrotalcite, 194.
Hydrozincite, 157.
Hypersthene, 244.
Hypersthenyte, 450, 451.
Hyperyte, 450.
Iberite, 315.
Ice, crystallization of, 4.
Iceland spar, 215.
Idocrase, 261.
Idrialine, Idrialite, 834.
Ihleite, 182.
Ilmenite, 178.
Ilvaite, 263.
Inclusions, 423.
Indianite, 275.
Indicolite, 283.
Infusorial earth, 941.
Iodargyrite, $1 \vartheta 1$.
Iodide, Mercury, 120.
Silver, 121.
Iodyrite, 121.
rolite， 264.
Hydrous， 315.
Ionite， 825.
lridosmine， 127
Iron， 171
hon，Ores of， $171,455$.
Maynetic，178， 455.
pyrites， 172.
sinter， $1 \times 5$.
Ironstone，（＇lay，17\％， 181.
Isembe， 448
lserine，o．Monaccanite．
Isomasite，1：3）
Itabyrite，440， $4 \pi \overline{3}$
ltacolumyte．104，485．
Itherite，dão．
lxolyte， 324.
Jade， 250.
Jucheite， 2033 ．
Jumesonite．149．
Jararon，260．
Jarosite，18：．
Jaspr，2：37．
rock， $1: 7$
daspery clay roustone， $17 \%$
Jeflerisite， 317
Jeffersonite ：D14
Jelletire，dis．
Jenkinsite，：30日．
Jemzehite，： $2+1$.
Jat，准）
Johanmite， 171.
Jollyte，sili．
Juseite，102．
Kalinite，198．
Känmererite，a18．
kancite， 1 ss．
Kaolin，Kanlinitr， $280,310$.
Karyinite， 15 ．
Kcilhanite， $203,: 201$ ，
Kermesite， 101.
Kerrite． 318.
Fiersanton， 444
Kersantyte， 443.
Kerstenite， 150.
Freseritr， 20 ．
Kinzigyte， 444.
Kjeralfince，：0\％
Knebelite， 256.
Kobellite， 149.
Kochelite，： 0 0．

Kongsbergite， 11 ．
Königite，Königinc， 138.
Könlite， 824 ．
Köttigite，15ts， 167.
Kotschuberte， 319 ．
Kreittouite， $1!65$.
Krennerite， 116.
Krisurigite， 138.
Krönkite， 1 is．
Kupforite，eg ed
Kyanite，整
Labearlioryte 418.
Labradur foldequr， 266.
Labmotorite，${ }^{9} 76$.
Labratopate－diorytr， $4^{\circ}$ º．
Lagronite，18\％．
Lampadite， 190.
lamenkite， 151.
Lamite， 13 s
lanthanite，20\％．
Lanthanmores，sol．
Lapis－lazuli，20）
Lathe ollayis，：301．
Larderellite， $3: 81$.
Latrohite，r．Anorthite．
Laumentite，Lammonte，det．
Lamite， $1=7$.
Lazulite， 199.
Lead，ores of，145
Leadhillite，lisl．
Lecontite $2: 31$ ．
lederite，＂g1．
Lehrbachite， 149.
Lemanite，：81？．
Leoprdite，$r$ ．Sylvite．
Lapidokrokite，18゙れ．
Lepirlolite，Dis．
Lepidemelame， 2066 ．
leptinvte，4：89．
Lettsomite，$x$ ．Cyanotrichite．
Leuchtenbergite， $81 \%$ ．
Leucite， $2 \pi 1$
Lencitophy re，402．
Leucityte， 433.
Leurophanite，呈mi．
Leucoprrite， $17 \%$.
Levy ue，Levynite， 301.
Lherzolyie， 453.
Libethenite， 139.
Liebigite， 151.
Lievrite，$c$ ．Ilvaite．
Liguite， 828.

Lillite, 316.
Limbachite, 309.
Limburgyte, 453.
lime-titanate, r. Perofskite.
Limestone, $216,430,432$.
Limnite, 182.
Limonite, 181.
limarite, $1: 38$.
Lindackerite. 168.
linneite, 164.
Liroronite, 139
Lithiophilite, 190
Lithium phosphates, $190,190$.
Lithomraphic stone, $21 \%$.
Lithomarge, :312
liver ore, 189.
Livingstonite, 101.
Lodestone. 141, 179.
Looss, 4?!
Loganite, 318.
Lollingite, 176.
Lephoite, 319.
1äweite, 237, :206;
Lüwigite, 199.
Loxoclane. 2\%s.
Ludlamite, 185.
Ludwimite, : 206 .
Lamachelle, 431.
laneburgite, 207.
1.ydiau stone, $23 \%$

Lyneurinm. 284.
Macle. 28.5.
Maconite, 318
Magnesite, 207.
Maguesium, Compounds of, 204.
Magnetic iron ore, 178.455. pyrites, 1 it
Magnetite, 59, 178, 4:23.
Marnoferrita, :04.
Marnolite, 129 .
Malachite, Blue, 141.
Green, 140, :200.
Malaculite, 246.
Matacom, 260.
Maldonite, 110 .
Malinowskite, $13 f$.
Manganblende, 188.
Manganepidot, v Epidote.
Manganese ores, $188^{\circ}$.
spar, 247.
Manganite, 189.
Marble, 216, 431, 432.

Marble. Verd-antique, 454.
Marcasite, 174.
Margarite, $: 819$.
Margarolite. 313.
Margarophyllite Section, 304.
Marialite, 269.
Marl, 482.
Marmatite, 1 Sphalrrite.
Marmolite, :30s.
Marsh gas, isel.
Martite, $1 \% \%$.
Mascagnite, Mascagnine, $\lesssim 31$.
Masonitr, $3: 0$ ).
Mathockite - Lead oxichloride.
Merdidite, 121.
Meerschaum, 306.
Meionite. 269.
Melaronite, 137.
Melanite, 258.
Melanochroite, 151.
Mrlanolite, 315.
Melanophlogite, "41.
Melanterite, 18.
Welaphyre, 450.
Melilitr, Mellilite, 261.
Melinophane, 250 .
Mahpanitr, 205.
Mellite, 201 .
Menaccanite, 178
Meudpite, 149.
Mendozite, 1 !s
Meneghinite. 149.
Menilite, 240.
Mercury, Ores of, 128. Nutive, $1: / \mathrm{K}$
Mesitine, Mesitite, 186.
Vesolite, 290.
Mesoryper. Natrolite.
Metabrushite, :14.
Metachlorite, 319.
Metarinmabarite, 129.
Metadoleryte, 452.
Metaxite, 308.
Metaxoite, 317.
Miargyrite, 120.
Miarolyte, 488.
Miascyte, 444.
Mica, 265.
Mica argillyte, 441. dioryte, 444.
phyllyte, 441.
schist, 440.
Michaclsonite, 263.

Microcline， 278.
Microlite，202． 214.
Microlites，416，fig． 6.
Microsommite， 270.
Middletonite， 325.
Milarite，2im．
Millerite， 164 ．
Millstone grit，420．
Mimetene，Mimetite，46， 15 ．
Mineral coal， $3: 7$ ．
oil， 321.
pitch，${ }^{2}$（ 6.
Minette，441．
Minium，144．
Mirabilite，41，$\underset{2}{2} 6$ ．
Misenite， $22 \pi$ ．
Mispickel， 1 nis．
Mizzonite， 269
Mochastome，2：3f
Molybdate，lead， 151.
Molybdenite， 96.
Molybdite， 97 ．
Monazite，41，${ }^{2} 03$.
Monisuolite， 15 ．
Monradite，20\％
Montanite， 103 ．
Monticellite，250．
Montmartite，or Gysum．
Montmorillonite， 30 ：
Montronite， 307.
Moonstoue， $277,279$.
Mordenite， 304
Morenositr， 168.
Mosandrite， $2(33$ ．
Moss agate， 236 ．
Mottramite， 139.
Mountain cork，250．
leather， 250.
tallow，3： 4
Muller＇s glass，： 240 ．
Mundic． 174.
Muntz metal， 144.
Muriatic acid，2：31．
Muromontite， $20 \%$ ．
Museovite， $267 \%$ ．
Muscovy glass． 268
Musenite，$v$ ．Siegenite．
Nadorite， 152
Nagragite，116， 149 ．
Naplitha， 321.
Naphthaline， $3 \geqslant 4$ ．
Natroborocalcite， 919 ．

Natrolite， 299.
Natron，2？O．
Naumannite， 118.
Needle ore，$v$ ．Aikinite．
Neft－gil， 324.
Nemalite， 204
Neotocite， 316.
Nepheline－doleryto， $45 \cdots$ ．
Nephelinyte， 4 ．
Nephelite，Nepheline， 209.
Nephrite．De0
Newjanskite， 127.
Niccolite， 166.
Nickel glance，v．Gersdorffite．
Nickel－rymmite， 309
Nickel，Ore＇s of， 164.
stibine， $1(6 f$ ．
Nirrine， 163 ．
Niolite，r．Columbite．
Niobium，（ompenands of， 184.
Nitrate，Calcium， 214 ．
Potassium， 2 必。
Sodium，：20．
Nitratius，2：0 9
Nitsr，量8
Nitrocalcite， 214
Nitromagrosite， 20 ．
Nohlite， 20 ）．
Noryte， 450
Nuspan，Nosite，2＂0．
Nommeite，lis
Novaculyte．436，453．
Nut1alite，26！）．
Ochre，Red，16；7， 176.
Yellow，181
Octahedrite，10：3
Ollarherite， 314.
Usictedite，200．
Orcuiter， 319
Okenitr， 293.
Oligoclase，44， 276.
Olivenite，189．
Olivine， 255.
Onyx，236．
Öilite，216．
Opal， 239.
Opal，Jasper，刃40．
Ophiolite， 308.
Ophiolyte，454．
Ophite． 447
Orangite， 296.
Orpiment， 99.

Orthite， 263 ．
Orthoclase，44， 278 ．
Ostenlite， 213 ．
Ottrelite， 820 ．
Onvarovite，：D8．
Oxide，C＇obalt， 167 ．
Iron， 176
Lexd， 149.
Muernasium， 204.
Manganest： 188.
Tin， 146 ）．
Tranium， 169.
Finc，15．
Ozarkite，：9R．
Ozucurite，Ozukerite，324．
Fuchmolite，19\％．
Paros， $1: 21$.
［＇agodite，：312
＇aluconite，：＇10，
Palladium，1ご。
Paraffin，：；） 1.
Paragonite，：314．
mehist，44．
Jaranthine ，2bo．
Pumaiter， P Buracite．
Parassitt． 251.
Parisite， 203.
larophitr， 314.
Parophito sthist， 441.
Tattersonite，：sll

Pesml sinter， $4: 37$.
spar． 219
stonc．44\％．
Pectolite．end．
Jexanite 200.
Peqmatolite，orthoclase．
Permatyter，4： 8.
Prlacrite， 189.
Pelhamite，；18．
Tencil－stone， 306 ．
Pennine ${ }^{\text {P }}$ Prminite, 318
Prinnitr， $2: 0$ ．
Teperino， 409
Fericlase，Periclasite， 204.
Peridkt，？．Chrysolite
1＇eridortete，451．
1＇erofkkite．Perowskit， 103.
Jetalite， 248.
Petroleum，321．
Petrocilex， 442.
Petzite， $116,118$.

Phacolite， 301.
Pharmacolite， 214.
Pharmacosiderite， 185.
Phenacite， 254.
Philtipite， $1: 38$.
Phillipsite， 302.
Phlogrojite， 68,266 ．
Phonicochroite， 151.
Pholerite，312．
Phonolyte， 444.
Phosgenite， $15 i 3$.
＇hosphate，Aluminum，199， 200.
Ammonium，wel．
（alcinm，212，¿14．
C＇erium， $20 ; 3$ ．
（opper，lise．
lron，184，185， 191.
1．ead， 151 ．
Mancranese，190， 191.
Traninm， 170.
Vtteium，：03．
Phonphochalcite，J 89.
Phonphorite， 213 ．
1＇hernite，295．
1hyllite，3：0．
lhyllyte，428．
Physalite， 287.
Pickrringite， 198.
l＇irotite，195．
l＇iculite，308．
licromerite，20
Piexofhyll， 295.
Picrusmine，－955．

＇ifelmontitr，atiw．
「ilinite， 304 ．
I＇mulite， 16 K ．
Pumbite，Por．
linile，：312．
Pinitoid，：31ゝ．
Pipe－clay，42\％．
Pipestone，499．
Pisanite．180．
Pisolite， 216.
Pistacite， 26 O ．
Pitchblende， 169.
Pitkarandite， 965 ．
Pitticite，$\because$ Iron Sinter．
Placioclase， $2 \% 5,425$.
Plarrionite， 149.
Plasma， 237.
Plaster of Paris， 211.
Platinum，Native， 124.

Platiniridium, 127.
Pleonaste, $x$. Spinel.
Plumbago, 107.
Plambic ochre, 149.
Plumbogummite, 149.
Plumose mica, : 267 .
Polianite, r Pyrolusite.
Polishing powder, 430.
Pollucite, Pollux, $25{ }^{2}$.
Polyargite, :113.
Polvargyrite, 120 .
Polyhasite, 120, 136.
Polycrase, 202.
Polyhalite, 20;, 227.
Polylite, 24
Polymignite, 202, 260 .
Porcelain jasper, 442.
Porchlanyte, 42.
Porcerlophitr, sos.
Porfide verde antico, 459.
!orpozite, 127
I'ophyrite, 44 .
Porphypitie stricture 415.
P'orphyry, 417, 442, 448.
Anticue gram, 45 m .
Antifue red, 415, 4 . 7 .
Porpherytr, 4t.
Portor, i: $: 1$.
Potassium, Compounds of, 223.
Potstone, :304.
Potter's clay. 429.
Pozzutam, t28.
Prase, e935.
Pregattite, 314.
Prehnite, 295.
Priesite, 212.
Prochlorite, 54, 319.
Propgiyte, 447.
Irotogine. 140.
Protovermienlite, 318.
Proustite, 119, 121.
Przibramite, 159.
Psammite, $v$. sandstone.
Pseudomalachite, 133.
Pseudophite, 318.
Pseudotriplite, 191.
Psilomelane, 189.
Psittacinite, 139.
Pudding-stone, 426.
Jurple copper, $r$. Bornite.
Pycnite :887.
Pyrallolite, e95.
Pyrargillite, 315.

Pyrargyrite, 119, 121.
Pyrencite, 258.
Pyrite, 5, 6, 1 \%2.
Pyrites, Arsenical, 175.
Auriferons, 173.
('apillary, 164.
Cobalt, 164.
Cockscomb, 174.
Copper, 133.
Hepatic, 1 at.
Ironi, 172.
Magnetic, 174.
Radiated, 174.
Syar, 174.
Variegated, 134.
White irm, 124.
Parochore, 20), 214.
Pywehroite, 189.
Pymbunity, $18 x$.
Pyromorphite, 17.
『yrope, 2is.
P'yrophonphorite, 214.
Pyrophyllite, Bug. slate 4 an.
Prophylyte, 45.
Pymophysalite, 287.
Pyroselerite, 317.
Pyrosmalite, $\times!6$.
Pyrosti!pnite, 120.
Pyroxeme, ©45.
Pyroxenyte. 45 .
Pyrmpurciton, 445.
Pyrmoniderite, 182.
Pyrrhotite, 1it.
Quartz, 533, 54, 54, 233, 233, 435,
andescte. $44 \%$.
diorytie, 41 l.
filsyte, 442.
propylyte. 447.
syenyte, 445.
trachyte, 442.
Quartzyte, 435.
Quick lime, 217.
Quicksilver. See Mercury.
Raimondite, 182.
Realgar, 99.
Red antimony, 101.
chalk, $17 \%$.
copper ore, 136.
hematite, 176.
lead, 149.

Red ochre, 167, 176.
silver ore, 119.
zinc ore, 150.
Reddingite, 191.
Redruthite, 132.
Refdunskite. 308.
Remingtonite, 168.
Rensselacerite, 305, 454.
Retinalite, 308.
Rhabdophane, 203.
Rhartizite, 286 .
Rhodinm gold, 110.
Rhodizite, 206.
Rhodochrome, 318.
Rhodochrosite, 191.
Rhodonite, 191, 247.
Rhoduphyllite, 318.
Rhomb-spar. 219 .
Rhyolyte, 418, fig. 8.
Ripidolite. 31\%.
Rittingerite, near Freieslebenite.
Rivotite, 139.
Rock eork, $v$ Horablende.
crystal, 234.
meal, 216.
milk, :16.
salt, $2 \underset{\sim}{2} 4$.
TRepperito, 256.
Romblerite, 207.
Rogernite, 203.
Romeine, Romeite, 214.
IRoseorlite, 314.
Roselite, 10 8 .
Rosite, 312.
Rosso antico, 415, 447.
Rothoflite, dis.
Röttisite, 168, 310.
Rubellite, :as?.
Ruby, Spincl, 198.
Ruby-blende, $v$. Pyrargyrite, 119
Ruby silver, 119.
Ruin marble, 431.
Ruthenium, Ores of, 127.
Rutherfordite, 20\%.
Rutile, 57, 16 :
Safflorite, 160.
Sahlite, $\approx 46$.
Sai ammoniac, 230.
Salmiak, 230 .
Salt, Common, 20, 224.
Samarslite, 170, 202.
Sandstone, 426.

Sanidin, 2\%8.
Saponite, 310.
Sapphire, 193.
Sarcolite, 269.
Sard, 233.
Surdonyx, 236.
Sartorite, 149.
Sascolite, Sassolin, 97.
Satin-spar, 210, 215.
Saussurite, $263,410,449$.
Saussurite group, 410.
Savite, $v$. Natrolite.
Scapolite, $2 f 8$.
Scurbroite, 290;
Sceleretinite, 30:
Scheclite, 212.
Sehillor-spar, 309.
Schorl (pron. Shorl), 983.
Schorlomite, 29.2 .
Schreibersite, 17\%.
Schrötterite, 296 .
Scolecite, Neolezite, 299.
Scorodite, 185.
Scotiolite, :315.
Selenate, Crpper, 135. Lead, 150.
Selcmide, Lead, 149.
Merciry, 149.
Silver, 118.
Selenite, 210.
Selenpalladite, 127.
St'miopal, : 240 .
Senarmontite, 101.
Sepiolite, $30 \%$.
Sericite. 314.
slate, 441
Serpentine, $30 \%, 454$.
Severite, 313.
Sieybertite, 320 .
Shate, $4: 7$.
Siderite, 185.
Siegenite, 164.
Silaonite, 102.
Silex, $p$. Quartz.
Silica, 233.
Silicate, Copper, 141, 142.
1read, 153.
Nickel, 165.
Zinc, 157
Silicates, 242.
Siliceous sinter, 240, 437. slate, 436.
Silicified wood, 238.

Silicoborocalcite, 212.
Sillimanite, 285.
Silt, 429.
Silver, 116, 1:1.
Compounds of : 216 . glance, 11 .
Sinter. Siliceous, 240.
Sipylite, 202.
Sisserskite, 127
Skutterudite, 166.
Smaltite, Smaltine, 16 .
Smectite, 307, 31~.
Smithsonite, 156.
Show, crystals of, 4.
Suapstonf, : $204,454$.
Soda nitre, DNO.
Sodalite, 270 .
Sodium, Compounds of, 223 .
Sommite, 269.
Spaniolito, 1:36.
Spathic irom, 185.
Spear pyrites, 174.
Speckstein, r. Steatite.
Specular iron, $176,45 \%$.
Syeculam metal. 144.
Spelter, 158.
solder, 144.
Spessartire, dis
Nphrmsiderite, 186.
Splaberite, 154.
Sphene: : 90.
Suherocolaltite, 168.
Spilite, 451.
Spinel. 194, 204.
Spinthere, r. 'Timite.
Spedumeme, 2ts
Stalactite, ilto.
Ntalagmite, 216, 4;
Stanuite, 159.
Staurolite, Staurotide, 291.
Steatite, 304.
Stearyte, 404
Stephanite, 119, 121.
Stercorite, $9: 31$.
Storlingite, $v$. Damourite.
St(rnbergite, 118.
Ntibnite, 100.
Stilbite, :802.
Stilpuomelane, 307.
Stinkstone, 217.
Stolperuite, 307.
Stolzite, 151.
Strakonitzite, 295.

Stratopeite, 816.
Strengite, 185.
Strigovite, 316.
Stromeyerite, 118.
Strontianite, 293 .
Strontium, ('ompounds of, $2 \geqslant 0$ 。
Struvitr, $2: 31$.
Stüle Jite, : 316 .
Ntylotypite, 136, 149.
succinum, $3: 5$.
Sulphate, Aluminum, 197, 198.
Ammonium, $2: 1$.
Barium, 20.
('alcium, „10, 211.
('ohalt, 168.
('omper, 1:37, 1:38.
Iron, 18\%.
Lead, 150 .
Magnesium, 205.
Nickel, 168 .
Potassium, 227.
Sodium, $2: 26,227$.
Strontium, 292.
Uranium, $1 \% 1$.
Zinc, 156.
Sulphide, Antimony, 100.
Arsenic, 99.
Bismuth, 102.
( 'admium, 159.
Cobalt, 164
('opper, 132, 13't, 134.
Iron, 120, $1 \%$.
Lead, 145, 149.
Manganese, 188.
Mercury, 10n, 130.
Molybdenum, 66 .
Nickel, 164.
Ruthenium, 127.
Silver. 117, 118.
Tin, 159.
Zinc, 154, 155.
Sulphur, Native, 3: 94.
Sulphuret, ser Sulphide.
Sulphurie acid, 96.
Sulphurous acid, 96.
Sunstone, $277,279$.
Susamite $=$ Rhombohedral Lead-
hillite.
Sussexite, 206 .
Syenites, 445.
Syenyte, 445.
gueiss, 446.
Sylvanite, 116, 118.

Sylvine, Sylvite, 224.
Syngenite, 227 .
Szaibelyte, 206.
Tahasheer, 2.11.
Tabular spar, 244.
Tachlyydrite, 20.
Tachyuphaltite, 2ito.
Tachylyte, 45 .
Taubilte, 189.
'Tale, siot.
'Taleose schist, 45t. slate, 411.
Tantalutes, 170, 184, 202, 214.
Tantalite, 184.
Tapalpite, 11 S .
Ta-manite, : 3 ,
Tellurate, Bismuth, 102.
Mercury, 120.
Telluride, Bismuth, 102.
(iold, 115, 116, 115.
lead, 149
Mereary, 129.
Silver, 118.
Tellurite, 96.
Tellurimm, Bismuthic, 102.
Foliated, a Nugyagito.
Graphie, 118.
Native, 港.
Tellarous acid, 96
Tengerite, 30;
Temmantite, 1305.
Tengrite, 137.
'Jephroite, 800.
Teremite, 812 .
Teschemarherite, 281.
Trschenite. 44
T'etradyinite. $10 \%$.
Tet rahedrite, $1: 1,135$.
Thenardite, 227
Thermonatrite, :30.
Thomsenolite, 197.
Thomsonite, 298 .
Thorite, 296.
Thraulite, :16.
Thalite, 263.
Thamite, 264.
Thuringite, 319.
Tiemannitt, 129.
Tile ore, 137, 160.
Till, 429.
Tin, Native, 159.
Tin ore, Tin stone, 160.

Tin prites, 150.
Tinkal, $222^{\circ}$.
Titanic iron, 178. 456. anite, 890 .
Titanium, Ores of, $16 \%$.
T'iza, r. Ulexite.
Tocormalite, 121.
Tonalyte. 447.
Topaz, 286
False. 23:
Ori-ntal, 193.
Topazolite, 2.s.
Torbanite, 325, : 29 .
Torb ruite, 100. 1:30.
Pourhstome. 23 .
Tourmaline, 380
Trachydoleryt., ai47.
Truchytr, 412.
Tractolyte, 450.
Trap, 4.1.
Traversullite, $2!$.
Travertine, tion
Trembhte, 240.
Trichiters, 416.
Triclasite, 315.
Tridymite, 8S, 241.
Tripestone, 210.
'Triphylite, Triphyline, 18t, 190.
Triphite. 191.
Triphoilite, 191.
Tripolite, $2-11$.
Tripolyte 480
Tritomite, 290 .
Trügrerite, 171.
'Troilite, 175.
Trona, 230.
Trommite, $15 \%$.
T'schelfkinitr, 203, 201.
Tschermakite, $n$ Oligoclase.
Tsherminite, 198, 2:31.
Tafa, Tuffe, 42
Tufa, (aleareous, 216 .
Tuumstate, Copper, 188.
Iron, 1 R3.
lead, 151.
lime, 2l®.
Tungstic oehre, 97.
Tungretite, 97 .
Turgite, $1 \times 2$.
Turquois, 200.
Tyrulite, 189.
Ulexite, 212.

Illmannite, 166.
Ultramarine, 270
Unakyte, 446.
Unghwarite, 30\%.
Unionite, v. Zoisite.
Uraconise, Uraconite, 1 1\%
Uralite, $24 \%$.
Uranin, Uraninite, 169.
Uranite, 170.
Uranium, Ores of, 169.
Uranmica, 170.
Tranochalcite, $1 \% 1$.
Uranocircite, $1 \% 1$.
Tranospinite, 170.
Uranotantalite, 170.
Tranritriol, 17.
Urpethite, 324.

Valentinite, 101.
Vanadate, Copper, 139.
lead, 152.
Vanadinits, 15a.
Variolytr, 449.
Variscite, 200
Vauquelinite, 151.
Velvet copper ore, 138.
Venerite, 319.
Venice white, 221.
Verd-antique, 308, 464.
Oriental, 415.
Verde di Corsica duro, 449.
Vermiculite, 817.
Vermilion, 129.
Vesuvianite, 261.
Veszelyte, 139.
Villarsite, 296.
Viridite, 317.
Vitreous copper, 132. silver, 117.
Vitriol, Bluce, 137.
Green, 182.
Iron, 189.
White, 156.
Vivianite, 184.
Voglianite, 171.
Voglite, 171.
Volborthite, 139.
Volknerite, 194.
Voltaite, 182.
Voltzite, 155.
Vorhauserite, 30k
Vulpinite, 212.

Wacke, 428.
Wad, 190.
Wagnerite, 206.
Walchowite, 325.
Walpurgite, 171.
Warringtonite, v. Brochantite.
Warwickite, 206.
Washingtonite, 178.
Water, 4, 231.
Wavellite, 201.
Whosterite, 199.
Wehrlite, 102.
Wernerite, 268.
Westanite, v. Fibrolite.
Wheel-ore, 136.
Whetstone, $436,453$.
White vitriol, 156. arsenic, 99.
Whitneyite, $135 \%$.
Wichtine, Wirlhisite, 252.
Willeosite, 320.
Willemite, 157, 256.
Williamsite, 30s.
Wilsonite, 312.
Winkworthite, r. Howlite.
Witherite, 221.
Wittichenite $=\mathrm{Cu}_{3} \mathrm{BiS}_{3}$.
Wittingule, :316.
Wöhlerite, 256, 260.
Wolfram, Wolframite, 183.
Wollastonite, :244.
Wollongongite, 320 .
Wood-opral, 240.
Wood tin, 160.
Woodwardite, near Cyantrochite.
Wulfenite, 151 .
Wurtaite, 155.

Xanthophyllite. 320.
Xanthosiderite, 182.
Xenotime, 203 .
Xylotine, 295.
Yenite, 263.
Youngite, 155.
$I^{+}$ter-garnet, 258.
Yttrium ores, 201.
Yttrocerite, 201.
Yttroilmenite, 170.
Yttrotantalite, 202 .
Zaffre, 168.


[^0]:    * A carat is a conventional weight, and ia divided into 4 grains, which are a little ighter than 4 grains troy; $741-16$ carat gruins are equal to 72 troy irains. The term chrat is derived from the name of a bean in Africa, which, in a dried state, has long been used in that country for weishng gold. These beans were carly carried to India, and were employed there for weighing damouds.

[^1]:    Marcasite or White iron pyrites. This ore has the same composition as pyrites, but differs in crystallizing in trimetic forms. $I \wedge I=106^{\circ} 36$. The color is a little paler than that of pyrite, and it is more liable to decomposition; hardness the same ; specific gravity 4.6-4.85. Radiated pyrites, Hepatic pyrites, Cockscomb pyritcs (alluding to its crested shapes, and Spear pyrites, are names of some of its varicties. It occurs in crystals at Warwick and Phillipstown, N. Y. Massive varicties are met with at Cummington. Mass.; Monroe, Trumbull, and East Haddam, Conn.; and at Haverhill, N. II.

[^2]:    
     besder 33 pere ent. a ammal matle 1

[^3]:    Auerbachite, Malacon, Tachyaphaltite, Eirstedite, Bragitc, are names of zircon-like minerals supposed to be zircon partly altered.
    The earth zirconia is aiso found in the rare minerals eudialyte and wöhlerite; also in polymignite, wselynite; also sparingly in fergusonite.

[^4]:    AINE
     rutile.

    Aroostoon.- Mefl hematite.
    Auburin.-Lepidolite, hebronite. grefon tourmaline.
    Bath.--- Vesuvianite, garmet, magmetite, graphite.
    Bethel.- Yinhamom girnct, calcite, sphene, beryl, pyroxene, hornblende, cpidote, praphite, tale, pyritヶ, arsenopyrite, magnetite, wad.

    Breginam.-Massive pyrite, galenite, blende, audalusite.
    Blat Ifmis Bay - Arsenical iron, molybderite! galenite, apatitc! fluorite! black fourmalime (Long Cove), black oxidr of manganesi (Usgood's farm), rhodonite, bog manganese, wolfrumite.

    Bowions.- Rose guartz.
    Bowdorvulam. - beryl, molybdenite.
    Bronswrk. - Greas mica, formt! black tourmaline! molybdenite. ("pidote, culcitc, musconit', feldspur", beryl.

    Buckrieln. - -Garmit iestates of Waterman and lawel, muscoviti! tourmaline! magnetite.
    (Ambage Farm.-(Nrar the tide mills), molybdenite, wolframite
    ('Amden.-Macle, grienit', 'pidete, black tourmaline, pyrite, tak, macnotite.

    Cakital (Penobscot. Co.)-Stibnite, pyrite, macle.
    Cominna. - - Pyrite, arscnopyritc.
    Deer Is le - Serpentine, verd-antique, asbestus, diallage.
    Dexter.-Galenite, pyrite, blende, chalcopyrite, green tale.
    Indfield. - Native copperas, graphite.
    East Woonstork.-Muscovite.
    Farmington.-(Norton's Ledge), pyrite, graphite, garnct, staurolite.
    Freepont.- Ruse quartz, garmet, feldispar, scapolite, graphite, muscovite.

    Fixeburg.-Garnet, beryl.
    Geongetown. - (Parker's Island), beryl! black tourmaline.

[^5]:    * See also the Report on the Nineralogy of Pennsylvania, by Dr. A. F. (enth,

[^6]:    Island - Pyritr.

    - A harmor.--On the shore, pifrit.!
    (1) Thla--Fildspart.

    Ge ind, one of the Wadham group- - (Ifrtempyrite.
    Bay.-On the shore south of Brigus, bornito and gray
    coppe
    Bay o vos - Southern shore. pyrite in slate.
    Lawn.-is. dite, cerrergyrith, proustite, argemiti.
    placentia bay.-At la Manche, two miles eastward of little Southern Harlor, galcuite !; on the opposite side of the isthmus from Macentia Bay, barite in a large vein, occasionally accompanied by chaleopyrite.

    Sioal Bay.-South of St John's, chalconyrite.
    Thinyty Bay.-Western extremity, harite.
    Ilambor Great St. Lawhence.-West side, fluorite, galenito.

[^7]:    * In whinc the spral halance of Jolly (pare (6), the spiral aprine io put at any deFired heipht 1 y means of the midng rod (: The rand B is ramed wo that the bower pan, $d$, shall be m the water, whe the other, $\subset$, subere it. The perathom of the index, or signal, $m$, is then moted, hy sightug acroce it and ohserving that the madex and the image of it in the muror are in the same horizontat line ; let $x$ stand for it. Next pat the frament of the mineral inc. and drop the stand 1 t until the lowe pan hangs fre in the water, and note the positson of $m$, which we may repectut by $t$; $t-s$ will equal the wedght in the rin. Non phee the fragment in the lower pan, and after adjuting again the stand $\overline{\mathrm{B}}$, the pontion of $m$ is noted a befobe; wall it $1 /$. Then $t-1=$ loss of weight in water. From these values the repecitic sravity inat once obtainced.

[^8]:    * Exposition Universelle de 1873 à Venue, p. 401-432; and Anuales des Ponts et Chaussées, $1893,1868,18 \% 0$

